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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the launching of the carrier-rocket and the spaceship "Vostok-4"

On the 12th of August, 1962, we, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, bear witness to the launching of the rocket carrying the spaceship-sputnik "Vostok-4", piloted by pilot-cosmonaut Pavel Romanovich POPOVICH.

The launching was made at 8:02:33 a. m. GMT from a cosmodrome near the station Baikonur.

The lift-off of the rocket took place at 8:02:33 a. m. GMT.

Time was measured by the stop-watch, type "Omega", No. 26, the accuracy of which is presented in the Appendix.

The geographical coordinates of the launching site are:

47°22'00" N. Lat.
65°29'00" E. Lon.

APPENDIX: The copy of the certificate, No. 848 of the stop-watch "Omega", No. 26.

I. G. Borisenko.
N. K. Nikitin.
sports commissars of the USSR Tchkalov Central Aero Club.

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COPY

THE COMMITTEE
OF STANDARDS, MEASURES AND MEASURING INSTRUMENTS
AT THE COUNCIL OF MINISTRY OF THE USSR
The state measuring instruments laboratory, AURDI

CERTIFICATE No. 848
on the state test of stop-watch No. 26

Range of measurements 60 sec. 60 min.

Type "Omega"

System

Manufacturer

Possession: the USSR Tchkalov Central Aero Club.

On the basis of state tests the instrument was adopted for use in the second class.

Laboratory Chief sign. *(Shayko)*

State representative who made verification sign. *(Menshova)*

The 13th of March, 1962.

THE RESULTS OF STATE TESTS

Corrections for the stop-watch:

the dial upward, per 60 sec. 00
" " " per 30 min. 00
the head upward, per 60 sec. 00
" " " per 30 min. + 1.2
The null position of the second needle 00
Temperature + 20° C

State representative who made verification sign. *(Menshova)*

The certificate is copied exactly. *The executive secretary of the sports commission* *(Golovanov N. M.)*

12 - 1962

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the landing of pilot-cosmonaut Andriyan Grigoryevich NIKOLAEV and the spaceship "Vostok-3"

On the 15th of August, 1962, I, the undersigned Ivan Grigoryevich BORISENKO, sports commissar of the USSR Tchkalov Central Aero Club, bear witness to the fact, that on the 15th of August, 1962, at 6:39:50 a. m. GMT pilot-cosmonaut Andriyans Grigoryevich NIKOLAEV was jettisoned from the spaceship-sputnik "Vostok-3" and at 6:52:00 a. m. GMT landed in the vicinity of the town of Karkaralinsk, Karaganda region.

The spaceship-sputnik with the identifying marks "USSR VOSTOK-3" landed at 6:44:09 a. m. GMT in the above mentioned region.

Time measurement was carried out with the stop-watch, type "Primator", No. 386673.

Geographical coordinates of the landing place of pilot-cosmonaut A. G. NIKOLAEV are:

48°02'00" N. Lat.
75°45'00" E. Lon.

Geographical coordinates of the larding of the "Vostok-3" spaceship are:

48°00'00" N. Lat.
75°45'00" E. Lon.

I. G. Borisenko,
sports commissar of the USSR Tchkalov Central Aero Club

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the landing of pilot-cosmonaut Pavel Romanovich POPOVICH and the spaceship-sputnik "Vostok-4"

On the 15th of August, 1962, I, the undersigned Nikolai Konstantinovich NIKITIN, sports commissar of the USSR Tchkalov Central Aero Club, bear witness to the fact, that on the 15th of August, 1962, at 6:46:21 a. m. GMT pilot-cosmonaut Pavel Romanovich POPOVICH was jettisoned from the spaceship-sputnik "Vostok-4" and at 6:59:00 a. m. GMT landed in the region of settlement Atasu, Karaganda region. The spaceship-sputnik with the identifying marks "USSR Vostok-4" landed at 6:50:37 a. m. GMT in the above mentioned region.

Time measurement was carried out with the stop-watch, type "Omega", No. 26.

Geographical coordinates of the landing place of pilot-cosmonaut P. R. POPOVICH are:

48°10'00" N. Lat.
71°51'00" E. Lon.

Geographical coordinates of the spaceship-sputnik "Vostok-4" landing place are:

48°09'00" N. Lat.
71°51'00" E. Lon.

N. K. Nikitin.
sports commissar of the USSR Tchkalov Central Aero Club

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on defining the distance of group flight of pilot-cosmonauts Andriyan Grigoryevich NIKOLAEV and Pavel Romanovich POPOVICH in the "Vostok-3" and "Vostok-4" spaceships August 12-15, 1962

We, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, and Alexandra Ivanovna SRAGOVICH, department chief of the Coordinating Computation Centre, have drawn up the following statement:

On the basis of studying the results of data processing of the measurement taken during the flight of the "Vostok-3" and "Vostok-4", spaceships on August 12-15, 1962, by the Coordinating Computation Centre, we have established the following:

The distance of the group space flight of pilot-cosmonauts Andriyan Grigoryevich NIKOLAEV and Pavel Romanovich POPOVICH in the "Vostok-3" and "Vostok-4" spaceship-sputniks amounts to 1975200 km.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

A. I. Sragovich,
department chief of the Coordinating Computation Centre

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on defining the group flight duration of pilot-cosmonauts Andriyan Grigoryevich NIKOLAEV and Pavel Romanovich POPOVICH in the "Vostok-3" and "Vostok-4" spaceships August 12-15, 1962

We, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN have drawn up the following statement:

On the basis of the statements of launching and landing and on the basis of studying the results of data processing of the measurements taken during the "Vostok-3" and "Vostok-4" flights, August 12-15, 1962, by the Coordinating Computation Centre, we have established the following:

The total group flight duration of pilot-cosmonauts Andriyan Grigoryevich NIKOLAEV and Pavel Romanovich POPOVICH from the moment of beginning the group space flight till the moment of finishing the group space flight is 70:23:38.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

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THE COORDINATING COMPUTATION CENTRE

"MOSCOW — COSMOS"

Results of data processing of orbital measurements obtained during the group flight of the "Vostok-3" and "Vostok-4" spaceship-sputniks on August 12-15, 1962, and defining the distance of the group flight

The data processing of the orbital measurements obtained during the group flight of the "Vostok-3" and "Vostok-4" spaceships on August 12-15, 1962, on M-20 and "Strela" electronic computers in accordance with the technique given below has made it possible to establish the following:

1. The minimum altitude of flight above the Earth:
   "Vostok-3" during the 17th turn: 178.0 km;
   "Vostok-4" during the 1st turn: 170.8 km.

   Geodetic coordinates of the minimum altitude point are:
   for "Vostok-3": φ = 42°23'30" N. Lat.
   λ = 62°06'50" E. Lon.
   for "Vostok-4": φ = 35°49'30" N. Lat.
   λ = 32°35'10" E. Lon.

2. The maximum altitude of flight over the Earth:
   "Vostok-3" during the 17th turn: 220.9 km;
   "Vostok-4" during the 1st turn: 236.7 km.

   Geodetic coordinates of the maximum altitude point are:
   for "Vostok-3": φ = 64°56'30" S. Lat.
   λ = 71°50'30" W. Lon.
   for "Vostok-4": φ = 63°49'15" S. Lat.
   λ = 86°55'50" W. Lon.

3. The geodetic coordinates, time (Greenwich) and the altitude of flight above the Earth for the two points are:
   "Vostok-3" during the 17th turn:

φ_1 = 44°.4 N. Lat.	φ_2 = 54°.8 N. Lat.
λ_1 = 63°.0 E. Lon.	λ_2 = 176°.4 E. Lon.
H_1 = 178.0 km	H_2 = 181.0 km
t_1 = 8 hr. 07 min. 00 sec.	t_2 = 8 hr. 24 min. 40 sec.

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7. The distance between the "Vostok-3" and "Vostok-4" spaceships was minimum at 8 hr. 16 min. 21 sec. a. m. GMT. At that moment the coordinates of the "Vostok-3" spaceship were φ 64°.992 N. Lat.; λ 121°.437 E. Lon.; H 180 km and the coordinates of the "Vostok-4" spaceship were φ 64°.993 N. Lat.; λ 121°.335 E. Lon.; H 184.5 km, the distance between the spaceships was 6.5 km. This point is assumed to be the beginning of the group flight.

8. The distance between the spaceships changed in the following manner:

1st turn of the "Vostok-4" spaceship	6.5 km;
17th turn	850 km;
33rd turn	1940 km;
48th turn	2850 km.

9. Pilot-cosmonaut A. G. NIKOLAEV jettisoned from the "Vostok-3" spaceship at 6 hr. 39 min. 59 sec. a. m. being at the point with coordinates φ 48°00'06" N. Lat.; λ 75°23'49" E. Lon.; altitude of which was 7 km above the sea level. At the same moment pilot-cosmonaut P. R. POPOVICH in the "Vostok-4" spaceship was at the point with coordinates φ 33°49'39" N. Lat.; λ 60°01'43" E. Lon.; H 90 km. This point is assumed to be the finish of the group flight.

The determination of the flight distance on the basis of orbital measurements carried out in accordance with the technique described below made it possible to state that the maximum flight distance from the point of beginning the group flight to the point of its finishing was 1975200 km.

The time elapsed from the moment of beginning the group flight up to the moment of its finishing was 70 hr. 23 min. 38 sec.

APPENDICES: 1. "The technique of defining the distance of group flight of pilot-cosmonauts A. G. NIKOLAEV and P. R. POPOVICH on the "Vostok-3" and "Vostok-4" spaceships".

2. "The technique of defining the orbit's elements of the "Vostok-3" and "Vostok-4" spaceships".

A. I. Sragovich,
department chief of the
Coordinating Computation Centre

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Technique of determinating the distance covered by the "Vostok-3" and "Vostok-4" spaceships during the group flight of pilot-cosmonauts A. G. NIKOLAEV and P. R. POPOVICH

The distance of the group flight of pilot-cosmonauts A. G. NIKOLAEV and P. R. POPOVICH in the "Vostok-3" and "Vostok-4" spaceships-sputniks was calculated with M-20 and "Strela" electronic computers.

The distance of the group space flight was defined as the sum of distances of two flight phases:

$$L = L_{act} + L_{act},$$

where L — total distance of group flight;

L_{act} — flight distance from the point of beginning the group flight to the point of firing the retrorocket;

L_{act} — the group flight distance from the point of firing the "Vostok-4" spaceship retrorocket to the point, where the "Vostok-4" spaceship was by the moment of jettisoning pilot-cosmonaut A. G. NIKOLAEV from the "Vostok-3" spaceship for landing.

The moment, corresponding to the minimum distance between the "Vostok-3" and "Vostok-4", spaceships-sputniks, reached after putting "Vostok-4" into orbit is assumed to be a beginning of the group space flight.

The distance for each phase of flight was estimated according to the formula:

$$L = \int_{t_1}^{t_2} \sqrt{V_x \cdot V_y \cdot V_z}\, dt,$$

where t_1, t_2 — time of beginning and finishing the movement on a given phase;

V_x, V_y, V_z — spaceship velocity vector components in the Cartesian coordinates;

V_x, V_y, V_z — of the Earth-satellite orbital flight phase were estimated by solution of the boundary problem, treating the motion of point in the gravitation field of the rotating Earth.

The initial data for the boundary problem solution were the results of measurements of the spaceship-sputnik movement parameters.

V_x, V_y, V_z for the phase from the moment of firing the retrorocket till the moment of finishing the group flight were estimated by solving the equation of motion using the known parameters of initial phase and introducing corrections with respect to the real coordinates of the landing point.

The flight distance was defined in the coordinate system, which moves in space together with the centre of the Earth.

Gurova, *A. I. Seagurich,*
department chief of the
Coordinating Computation Centre

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The technique of "Vostok-3" and "Vostok-4" orbital parameter calculation

The following basic assumptions on the spacecrafts' motion were made to determine the orbital parameters.

The satellite is treated as a mass point moving under the action of the Earth's gravitational force and the air drag one.

Expanding the g potential into spherical functions two components were taken into account, viz.: the uniform sphere potential and the term incorporating the Earth's flatness. Anomalies of the gravitational field were ignored.

The air drag deceleration was found by the formula

$$a = s\rho v^2, \qquad (1)$$

where v — a module of the vector of the satellite relative velocity,
ρ — the air density at a given altitude,
s — ballistic coefficient the value of which is determined by satellite weight and aerodynamic parameters.

The satellite is considered to move in $OXYZ$ Cartesian coordinates which are bounded rigidly to the rotating Earth. The origin of the coordinates is placed into the Earth's center, the OZ axis passes through the North Pole, the OX axis coincides with the Greenwich meridian and the OY axis is due East.

The satellite's orbital parameters were found on the basis of the processed tracking data by means of solving a boundary problem for the following system of the differential equations of motion:

$$\begin{aligned}
\dot{V}_x &= -s\rho V V_x - g_r \frac{x}{r} + g_m \frac{z}{r} \frac{x}{r} + 2\omega_3 V_y \\
\dot{V}_y &= -s\rho V V_y - g_r \frac{y}{r} + g_m \frac{z}{r} \frac{y}{r} - 2\omega_3 V_x \\
\dot{V}_z &= -s\rho V V_z - g_r \frac{z}{r} - g_m \frac{z}{r} \\
\dot{x} &= V_x, \qquad \dot{y} = V_y, \qquad \dot{z} = V_z,
\end{aligned} \qquad (2)$$

where $V = \sqrt{V_x^2 + V_y^2 + V_z^2}$, $r = \sqrt{x^2 + y^2 + z^2}$, $V_r = \sqrt{V_x^2 + V_y^2 + V_z^2}$

g_r and g_m are radial and meridional components of the Earth's gravity respectively (the positive values of them are to the center of the Earth for g_r and due south for g_m);

ω_3 — the Earth's angular velocity.

The initial data necessary to solve the boundary problem were the measured $x_i, y_i, z_i, V_{xi}, V_{yi}, V_{zi}$ ($i = 1, 2, \ldots, N$, where N is the total number of the measurements) and the calculated values of the initial motion parameters $\tilde{y}_j^{(0)}$ ($j = 1, 2, \ldots, 6$) related to the moment $t = t_0$ of the spacecraft insertion into orbit.

To determine $\tilde{x}_i, \tilde{y}_i, \tilde{z}_i$ it was necessary to measure the range D_i from the tracking station (TS) to the satellite D_i, the azimuth A_i of the "TS — satellite" line and the tilt angle φ_i of this line. Measurements were carried out by the tracking stations situated on the territory of the USSR along the satellite track. The tracking stations were equipped with the radiotechnical systems, using the principle of active response from the satellite and provided the necessary measuring precision.

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THE USSR TSIKALOV CENTRAL AERO CLUB

REPORT

on the "Vostok-3" and "Vostok-4" spaceship construction and their special equipment

The "Vostok-3" and "Vostok-4" spaceships are guided rocket vehicles. Their construction is similar to that of the "Vostok" and "Vostok-2" spaceships. The spaceships may be controlled both automatically and manually by the cosmonaut.

Each spaceship consists of a pressurized cabin, which houses the cosmonaut, of an instrument compartment and a retrorocket compartment.

There is a special heat shield on the outside of the pilot's cabin, that protects the cabin against the high temperature of reentering.

The cabin is equipped with two quickly opened hatches.

The cabin's shell has three windows for the cosmonaut to use for observations. The windows are provided with refractory glass, designed to withstand the high temperatures on the surface of the vehicle during reentry.

All the windows carry shutters which may be opened or closed either by an electrical drive or manually by the cosmonaut.

The spaceship's cabin houses a life-support system, a control system, food and water supplies, some of radio equipment, a binokular for observations through the windows, TV-cameras, a cinematographic camera for shooting a film through the windows and a cinematographic camera for shooting a film inside the spaceship.

The instrument compartment contains some radio equipment, control equipment, a temperature control system and an electrical power system.

In flight the cosmonaut is supported by a catapulted molded couch which is his working place and may serve as a means for leaving the cabin before landing. Supporting surfaces of the couch are fitted with soft plastic cushions.

The couch contains parachute systems providing the landing of the cosmonaut.

In case of water landing the cosmonaut may use a pneumatic liferaft inflated automatically.

If for some reason the cosmonaut cannot make use of the raft after water landing, a special device in the pressure suit keeps the cosmonaut lying on his back above the surface.

During the orbital flight ventilation of the cosmonaut's pressure suit is performed with the air taken out of the cabin. In case of the cabin's decompression the suit is automatically pressurized. In this case the reserve of the onboard compressed oxygen and air provide the oxygen supply to the cosmonaut for breathing and the air for ventilating the space suit. In case of decompression of the cabin the oxygen and air reserves allow the cosmonaut enough time to establish radio contact with the ground, to choose a place for landing and to descend.

The manual flight and descent control systems allow the cosmonaut manually to control the vehicle's attitude in space and to land the ship in the desired area.

The attitude control system provides a proper attitude of the vehicle before [illegible] is launched.

The system is divided operationally into an automatic one and a manual one.

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An optical orienting unit used by the cosmonaut to find out the flight direction and the local vertical is mounted on one of the cabin's windows.

The retrorocket with the control system is designed to change the magnitude and direction of the spaceship's velocity vector to transfer it from the [illegible] satellite orbit to a descending trajectory.

The retrorocket may be activated both automatically and at pilot's discretion by means of a switch on the instrument panel.

The flight control system provides automatic control of onboard instruments according to a prescribed programme.

The spaceship is equipped with radioequipment for two-way communication of the cosmonaut and ground stations during prelaunch operations, powered flight and orbital flight.

The radio equipment includes two short-wave receivers and two short-wave transmitters, an ultra-short-wave receiver and transmitter, a tape recorder, a broadcast receiver and electroacoustic equipment.

The frequencies of the onboard transmitters of the "Vostok-3" spaceship are 18.035; 20.006 and 144.150 megacycles per second and of the "Vostok-4" spaceship are 18.035, 20.006 and 143.625 megacycles per second.

The type of communication is chosen by the pilot switching on the proper radio system.

The tape recorder is switched on either automatically by the cosmonaut's voice sound or manually. Tape recorder data are radioed to the ground at an increased speed by the command from a receiving station when the spaceship is over it.

Orbit radio control of the spaceship equipment for the powered and orbital phases consists of receiving and transmitting signal forming instruments and an antenna system. The TV system is designed for watching the cosmonaut and receiving objective data on his state, behaviour, movement coordination while performing various operations.

Instruments for monitoring and recording physiological functions of the cosmonaut in flight, viz.: pulse rate, respiration etc., allow to conduct continuous observations of the cosmonaut's state.

Radio and telemetering equipment, self-contained regeneration system and sensors provide monitoring and recording of the onboard instruments performance in flight. In addition the spaceship carries the "Signal" radio system operating on the frequencies of 19.995 and 19.990 megacycles per second.

To maintain the basic microclimate parameters in the cabin within the limits close to normal a conditioning system is used which absorbs carbon dioxide and moisture and supplies the necessary amount of oxygen for pilot's respiration. The oxygen flow rate in the system is controlled automatically.

The conditioning system also absorbs the harmful contaminations which result from human life activity and instrument operation.

Normal cabin pressure is maintained with the help of a pressure control system. The food and water supply systems provide the pilot with food and water throughout flight.

The pilot has a four-meal diet. A special sanitary unit is designed for collection of liquid and solid excretion products.

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The automatic temperature control system is installed aboard the spaceship to maintain the temperature regime within given limits.

The system consists of two loops: an air-loop opened into the cabin and a liquid one, connected with a radiating heat source mounted on the instrument compartment. Both loops are connected to an air-liquid heat exchanger located in the cabin.

Such a system ensures the maintainance and control of the cabin temperature by the cosmonaut within the range of +12° to +27°C.

The cabin light system includes the "on-duty" illumination and the operational one. Illumination is controlled by switches on the instrumentation panel and may be turned on and off by the pilot. The system provides illumination from 5-70 luxes.

The landing system ensures a safe landing of the spaceship and the pilot during the last phase of descent.

A device for determining by the pilot of the spaceship's position in orbit and geographical coordinates of the expected landing point is made in the form of a globe scaled down to 100,000,000 times.

The globe rotates simultaneously around two axes. Rotation around one axis corresponds to the Earth's rotation taking into account corrections for the precession of the spaceship's orbit. Rotation around the second axis corresponds to the orbital movement of the spaceship.

Thus every moment under the cross lines marked on the face glass of the instrument a place appeares over which the spaceship is flying at this moment. Indication of the expected landing point is carried out by turning the globe about the angle corresponding to the angle of descent from the point of firing the retrorocket to the landing point.

The globe design permits to make necessary corrections to the instrument's operation in accordance with the real orbital parameters.

In contrast to the "Vostok" and "Vostok-2" spaceships the "Vostok-3" and "Vostok-4" spaceships have the following modifications. The spaceships carry the advanced TV-system to improve the quality of TV images sent from the ships. The water supply system is modified. To enlarge the volume of information on the cosmonaut's state additional instruments for measuring pilot's galvanic reflexes, taking electrical encephalogram and nystagmogram and transmitting them to the ground are set aboard the spaceships. Besides that additional instruments for recording the ionizing radiation dose are used.

The pilot's instrumentation panel is also improved and allows the cosmonaut to better control the spaceship's systems.

The couch, pressure suit and parachute system of the cosmonaut are modified too to increase the reliability and accessibility.

Improvements were introduced into onboard radio systems to provide communication capability between the "Vostok-3" and "Vostok-4" spaceships.

In addition to the modifications mentioned above some improvements were made as to the spaceship structure to increase the strength of some of its components and reliability of a structure as a whole.

P. F. Konstantinov, engineer

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Telemetering measurements of the "Vostok-3" and "Vostok-4" spaceships group flight

Group flight's telemetry information of the "Vostok-3" and "Vostok-4" spaceships piloted by A. G. Nikolaev and P. R. Popovich, respectively, had been conducted to obtain the following information:

the space flight similar conditions influence upon the human being,

the human being efficiency in zero-g conditions,

the establishment of direct communication between two spaceships during the flight and the establishment of coordinated operations of pilot-cosmonauts guiding those spaceships,

further improvement of spaceships' systems, communication facilities, control and landing ones.

The studies were made by means of readings of sensors and instruments, connected with airborne devices of the radio TM-systems.

The information from the spaceship was transmitted over the telemetering communication channels to the ground station, which received and recorded it.

Radio TM-systems recorded the information beginning with the pre-launch period, including the powered and orbital flight phases till the moment of spaceship brake.

During the spaceships' and cosmonauts' descent and landing the sensors readings were recorded by the self-contained memory devices.

The vital activity of cosmonauts A. G. Nikolaev and P. R. Popovich was recorded by TM-systems on the basis of the following biological parameters readings:

electrocardiograms
pneumograms
electroencephalograms
electrooculograms
skin-galvanic reflexes

Copies of portions of the cosmonauts' electrocardiograms, electroencephalograms, electrooculograms, and pneumograms are given below.

The basic biological parameters of cosmonauts A. G. Nikolaev and P. R. Popovich during different phases of flight are given in Table 1. The results of TM information treatment on basic biological parameters of cosmonauts A. G. Nikolaev and P. R. Popovich which are given in Table 1, are in direct accordance with their physiological characteristics during normal life and the pre-flight trainings on the ground.

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During the flight both cosmonauts felt fine. Their efficiency was on the high level. The cosmonauts completely fulfilled the flight programme. The determinations of summary radiation dose show that A. G. Nikolaev has got the summary radiation dose about 50 mrad during 4 days and P. R. Popovich has got about 36 mrad during 3 days flight. Each cosmonaut got about 12 mrad per day. Such a small radiation dose did not disturb the cosmonaut's vital activity.

TM measurements of sensors readings which characterize the operation of devices and systems providing the normal climatic conditions during the flight gave the following results. The results of the "Vostok-3" and "Vostok-4" spaceships TM information processing given in Table 2, witness the maintaining climatic conditions within the required limits and normal operation of all systems which provide these flight conditions.

For processing TM information the calibration data of sensors and instruments were used which fixed the processes and phenomena occurred on the "Vostok-3" and "Vostok-4" spaceships. These data were got in the course of the plant and complex joint tests of the spaceships and radio-TM systems.

The following figures show the examples of the calibration plots.

Engineer Ubasof *(S. M. Ivanov)*

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Table 1.

The flight phase	Cosmonaut A. G. Nikolaev		Cosmonaut P. R. Popovich	
	pulse rate	respiration rate	pulse rate	respiration rate
PRIOR LAUNCH PHASE	114	11	117	16
THE LAUNCH AND POWERED PHASES				
in the beginning of powered phase	120	14	124	15
in the end of powered phase	119	15	118	20
ORBITAL FLIGHT				
first turn	127	15		
second turn	100	14	75	23
18 "	70	21	52	17
34 "	52	18	55	15
40 "			62	21
50 "	72	14		
63 "	67	9		
initial breaking phase	87	14	136	21
reentry	102	12	159	27

Table 2.

N/N	Characteristics	Units of measure	Characteristics values for different phases						Precision
			"Vostok-3"			"Vostok-4"			
			prelaunch. and powered flight	orbital	descent	prelaunch. and powered flight	orbital	descent	
1	Air pressure inside the cabin	mm Hg.	765	765 ; 755	760 ; 500	770	770 ; 760	760 ; 500	±10 mm
2	Pressure in the spaceship	mm Hg.	765	765 ; 755		770	770		±10 mm
3	Air temperature inside the cabin	C	26	23 ; 13		28	28 ; 12		±1° C
4	Air composition in the cabin, oxygen CO	% %	21 ; 22 0.3	22 ; 25 0.3 ; 0.5	25	22 0.36	22 ; 25 0.3 ; 0.6	25	±2 % ±0.1%
5	Humidity level in the cabin	%	60 ; 65	70 ; 50		60	60 ; 40		±5%

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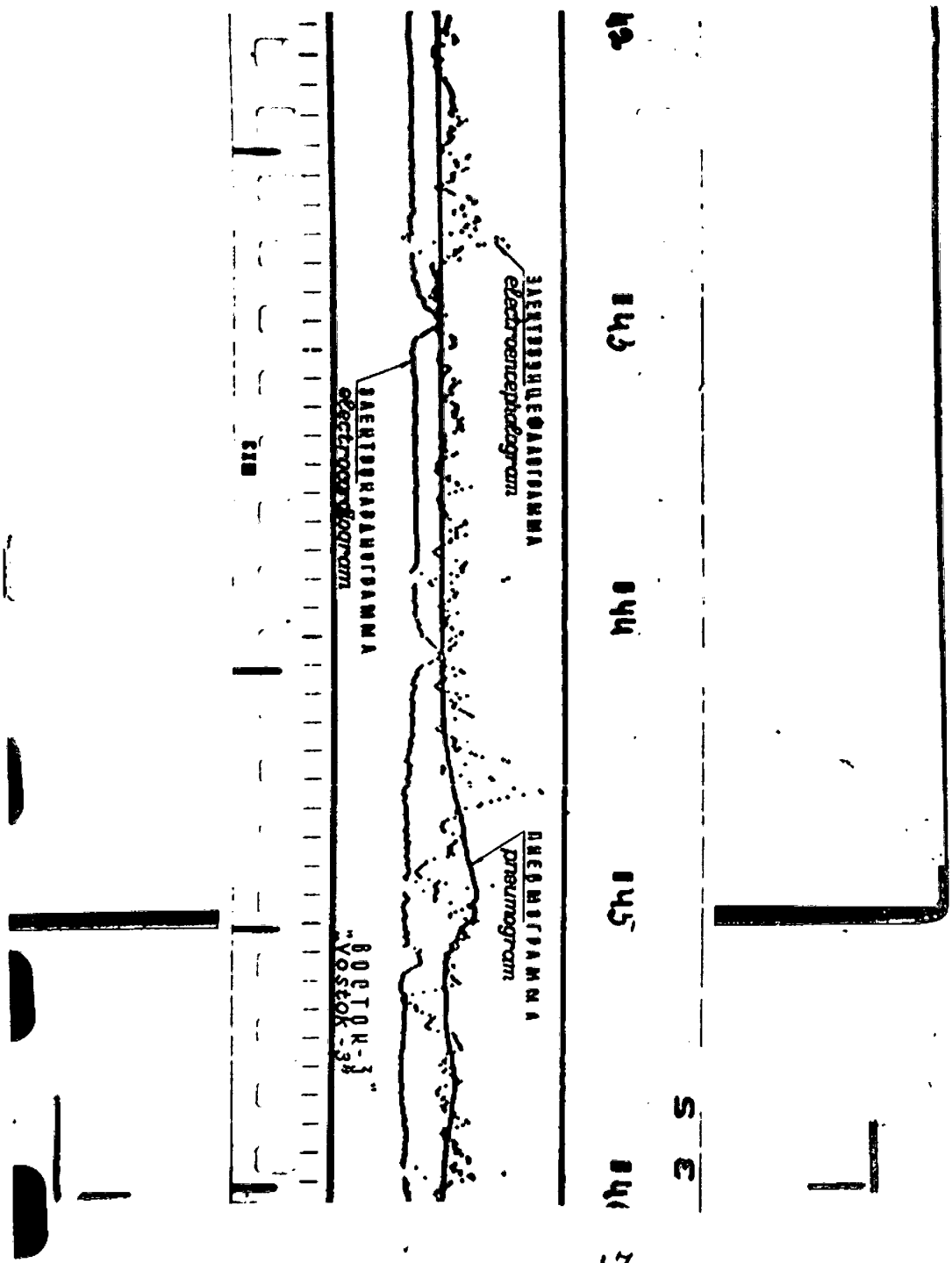

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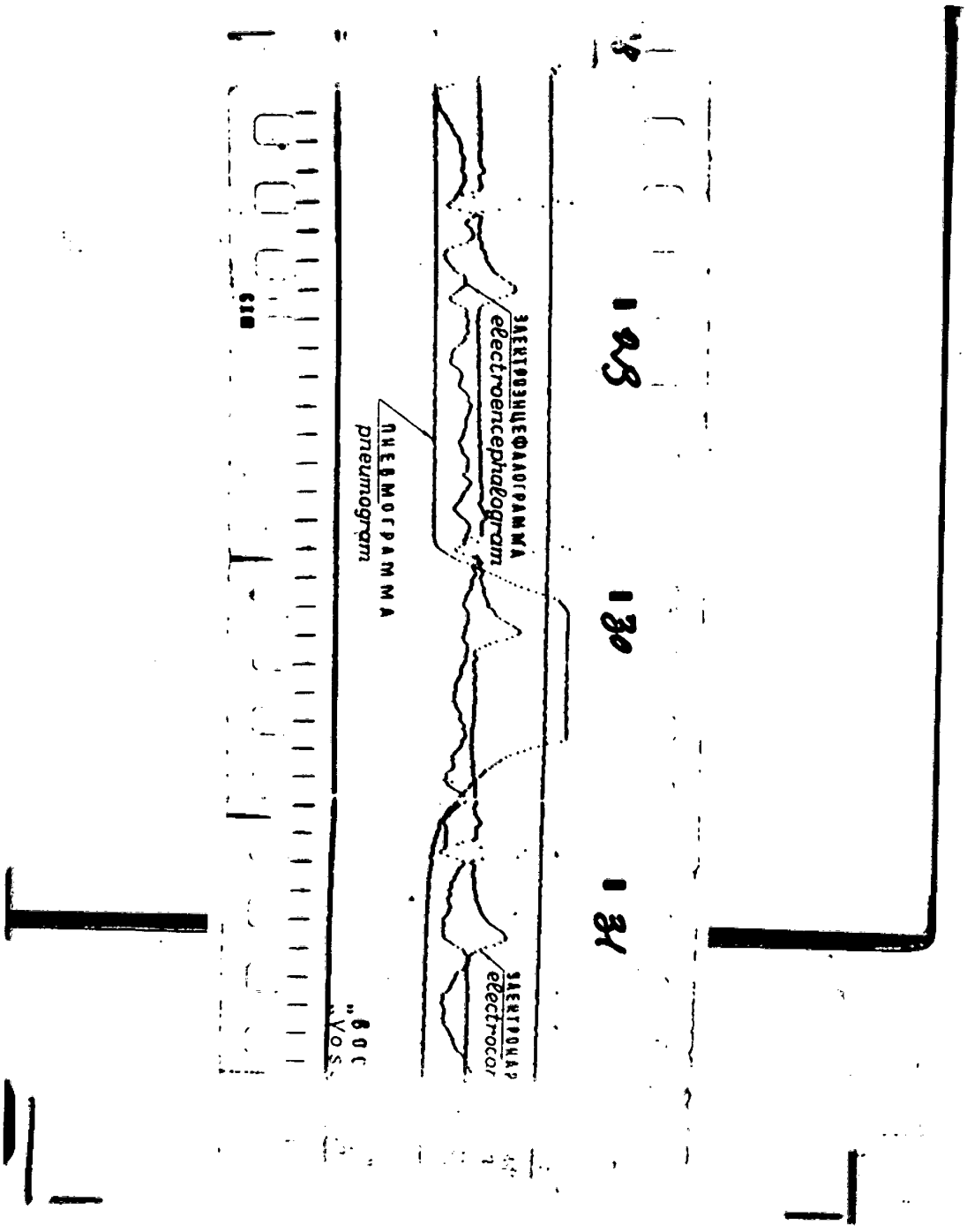

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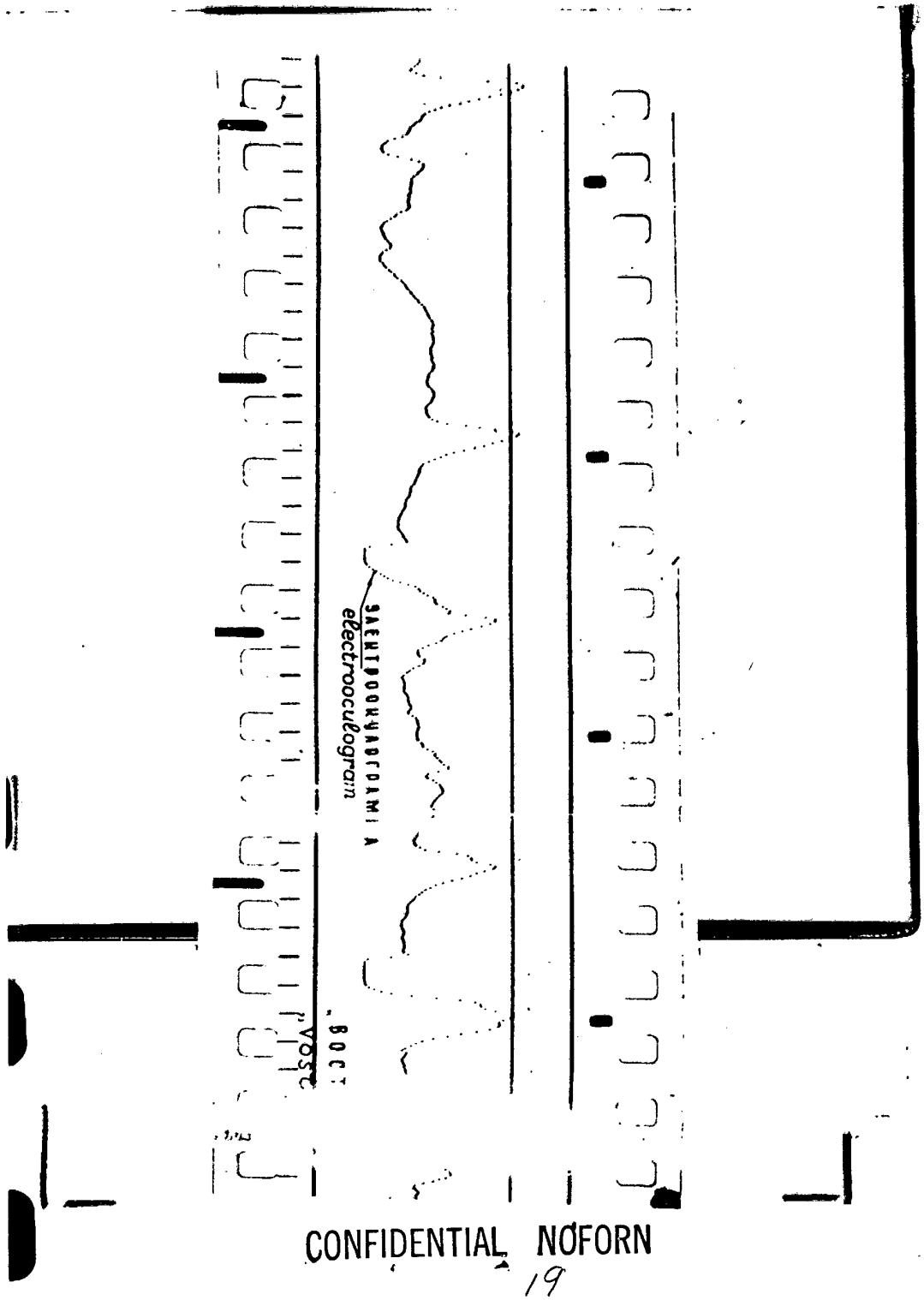

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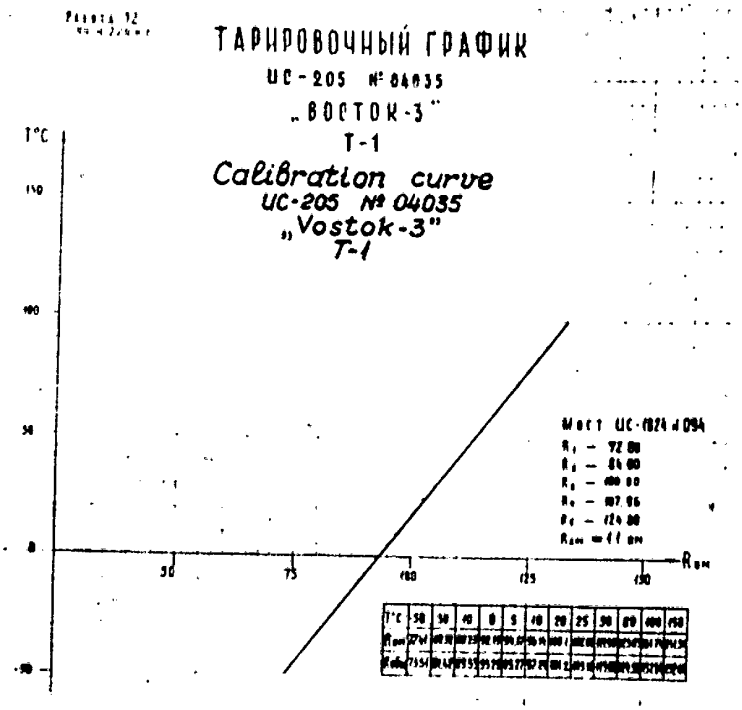

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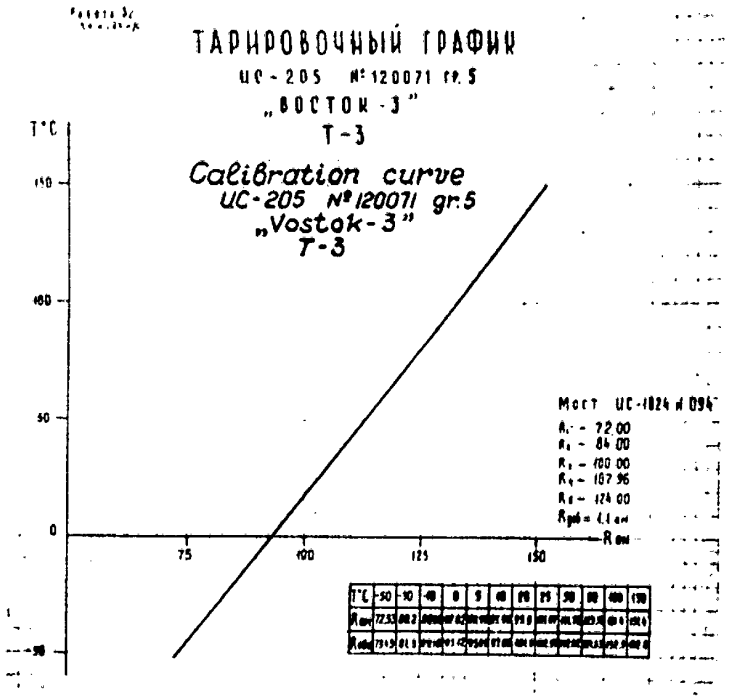

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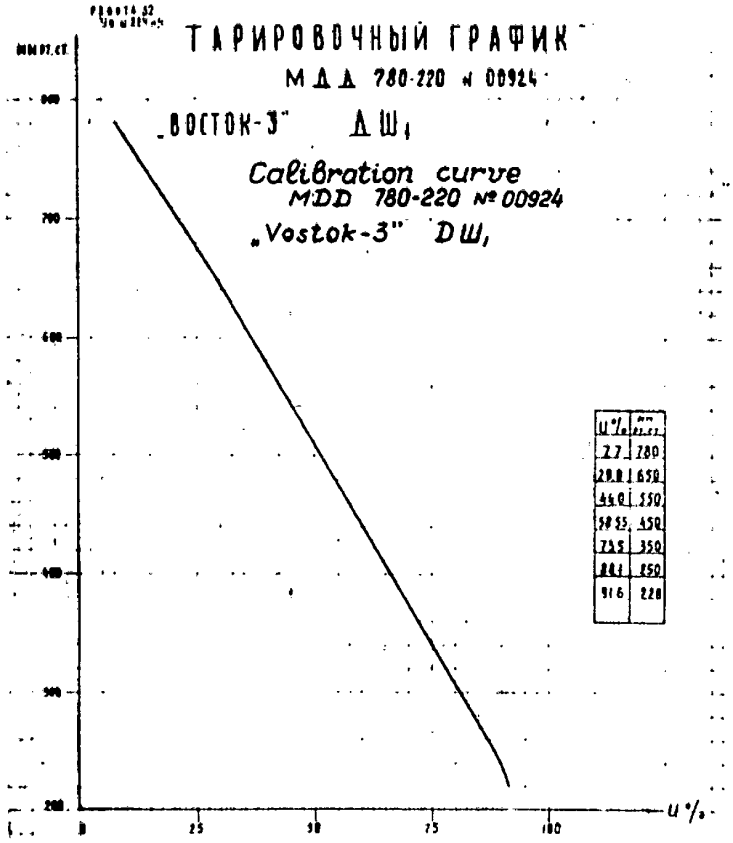

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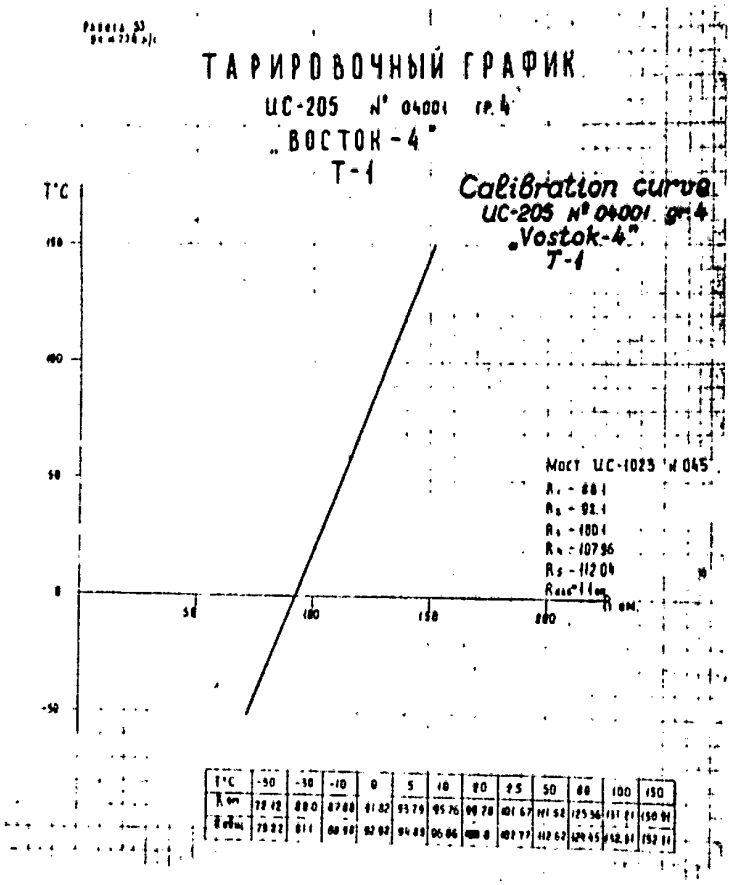

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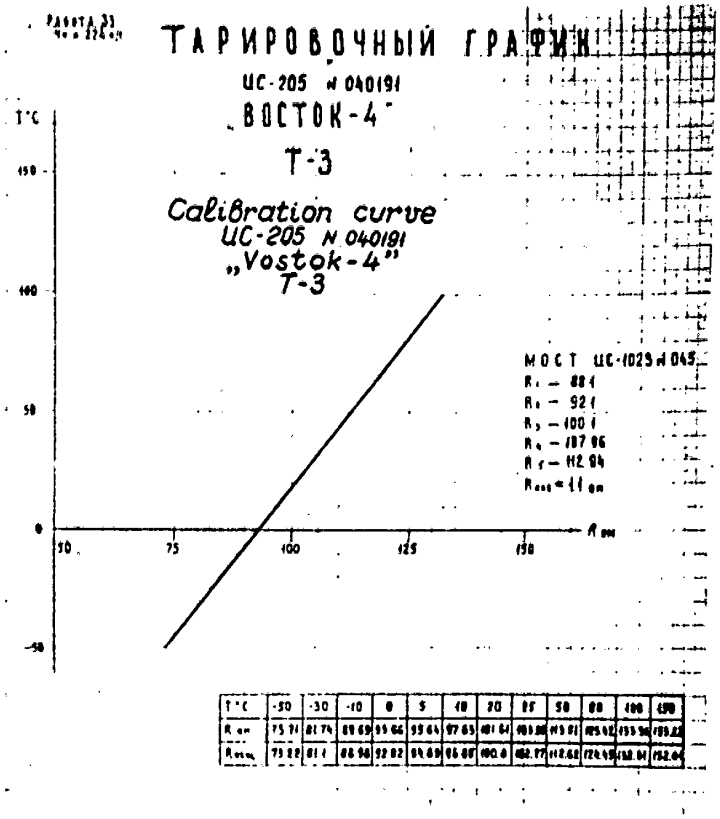

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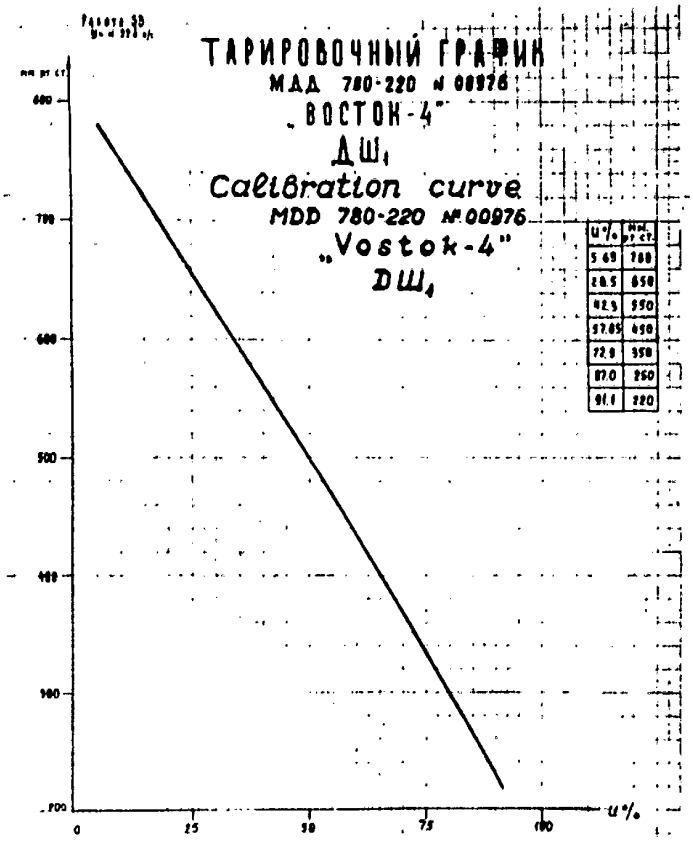

u %	мм рт.ст.
5.69	700
20.5	650
42.9	550
57.05	450
72.8	350
87.0	250
91.1	220

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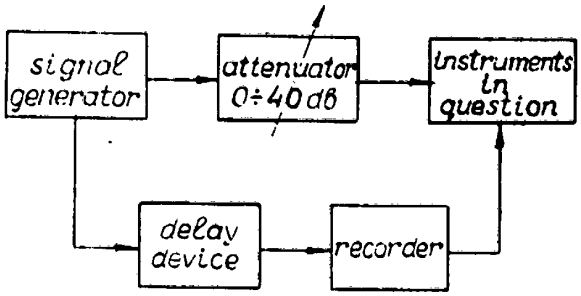
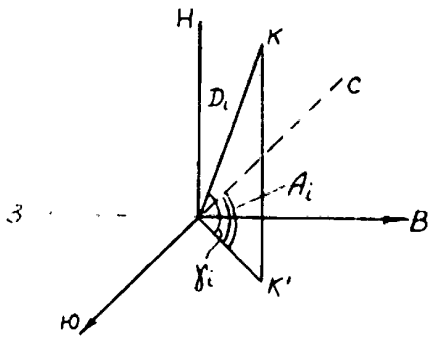
Delay time calibration





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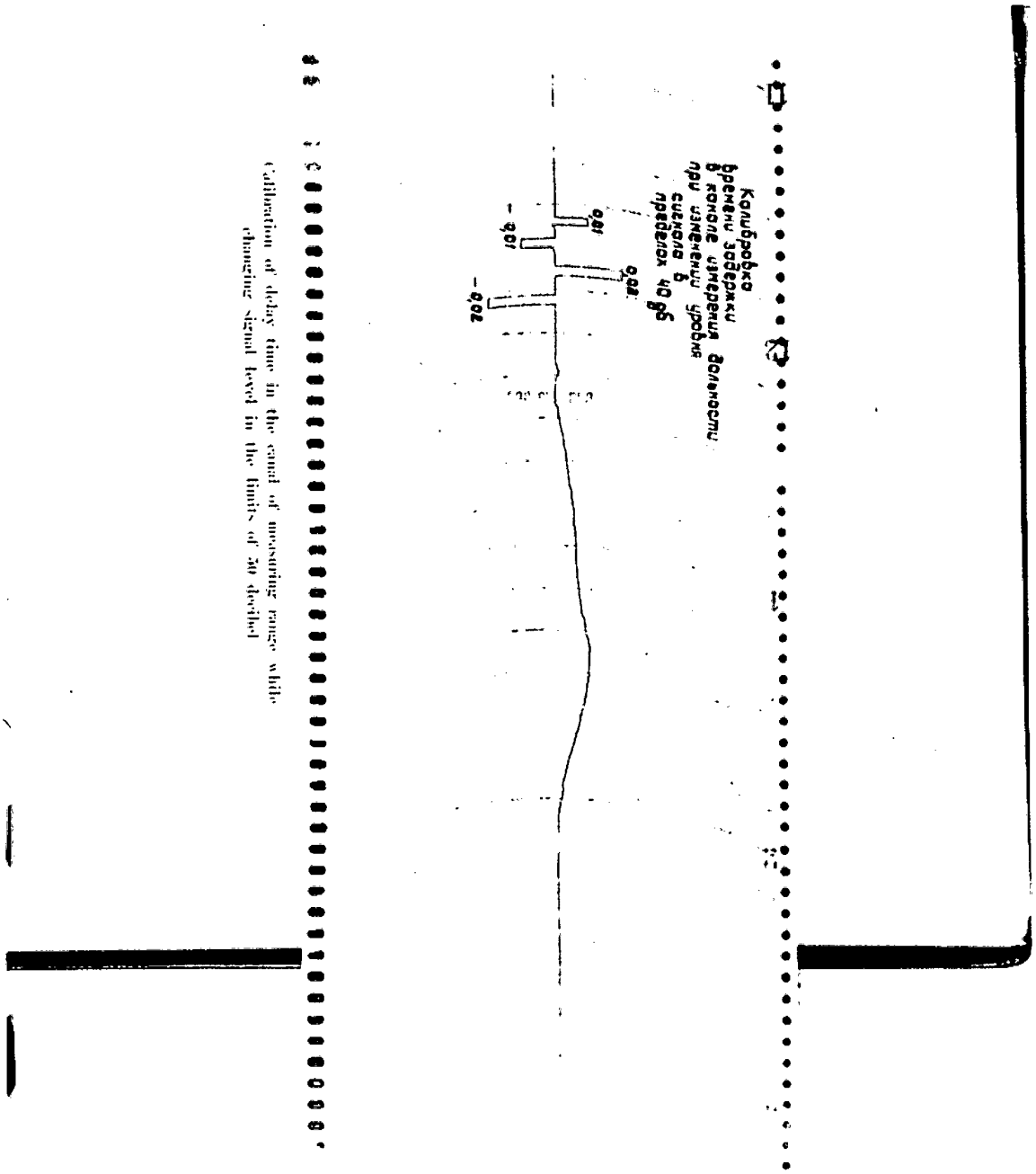

Calibration of delay time in the canal of measuring range while changing signal level in the limits of 40 decibel

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THE USSR TCHKALOV CENTRAL AERO CLUB

Brief description of measuring instruments and accuracy of measurements. Calibration curves.

Measurements were taken by the tracking stations located along the satellite ground track on the territory of the USSR.

The tracking stations were equipped with radars operating in the regime of active response from the satellite.

The measurements included slant range D_i from the tracking stations (TS) to the satellite, azimuths A_i of the lines of sight "TS-satellite" and tilt angles γ_i of this line, *(fig. 1)*. The measurements of slant range were carried out by defining time intervals between the moment when the signal was sent and the moment of its reception with the subsequent presentation of these periods in a binary code.

While carrying out measurements corrections to signals delay in ground and airborne instruments were taken into account. Corrections were found by means of special calibration of the measuring instruments during the prelaunch countdown (see Appendix). Corrections for radar measurements were also made during the intervals between the periods of communications with the satellite.

The azimuth A_i and the angle γ_i were defined with the help of track antennas and "shaft-figure" converters in the binary code.

The airborne instruments provided simultaneous communications with several ground stations in the regime of active response.

The airborne instruments were switched on for a limited period of time during the flight of the satellite over the regions of the Soviet Union where the tracking stations were located.

The results of the measurements were correlated to the standard time by means of high stable generators synchronized by radio lines with the accuracy of 1° in phase.

The precision of time correlation of the measured data at all tracking stations was higher than 10^{-4} sec. The radar information from each tracking site was automatically supplied through communication lines to the Coordinating Computation Centre and was simultaneously processed on M-20 and "Strela"-type electronic computers.

MEASURING INSTRUMENTS CHARACTERISTICS

Ground microwave radar stations.

The quality of measuring the slant range (D_i) is 25 meters not taking into account the instability of propagation velocity of electromagnetic oscillations.

The precision of measuring the angular position is higher than 1.5'.

Error values comprise calibration mistakes, viz.: less than 3 meters for range and 10' for azimuth and elevation.

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CALIBRATION TECHNIQUE

a) of ground stations.

Comparison of radar range with geodetic range measured with the precision of 0.2 m.

b) of airborne device.

Comparison between the radar range measured from the location of the radar station to the satellite antennas when the satellite is in the launching position and the geodetic range between these objects excluding instruments delays of radar stations, measured according to the item "a".

c) Calibration of delay time in measuring signal level.

The change of signal level causes variations in the delay time of a signal in measuring instruments, which leads to errors in range data.

Since these errors were neglected while measuring the "Vostok-3" coordinates the values of these errors must be provided to be small enough.

For this purpose appropriate calibrations were made, confirming the small values of the errors mentioned.

Calibration was carried out by recording signal delay time while changing signal intensity. The recording of the variations in the delay time of a signal in the measuring systems versus signal intensity (in strength) within the range of 40 decibel are presented in the calibration diagram.

The delay time variations from the mean value are plotted along the vertical axis, the signal intensity variations are plotted along the horizontal axis.

Calibration levels of delay time in microseconds (0.01; −0.01; −0.02; −0.02) are given at the beginning of the plot.

The calibration confirmed the possibility of neglecting errors, caused by signal delay-time instability in the range channel.

The maximum error was less than ±0.01 microsecond (±1.5 meters).

Engineer [signature] *(B. A. Fedorov)*

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THE USSR TCHKALOV CENTRAL AERO CLUB

DESCENT SCHEDULE
(GMT)

1. The spaceship-sputnik orientation system was switched on by the automatic descent system:
   on "Vostok-3" at 5:47:45 a. m.,
   on "Vostok-4" at 5:53:00 a. m.
2. The automatic descent system actuated the retrorocket:
   on "Vostok-3" at 6:24:08 a. m.,
   on "Vostok-4" at 6:29:52 a. m.
3. The automatic descent system exploded the lid of the catapult hatch:
   on "Vostok-3" at 6:39:57 a. m.,
   on "Vostok-4" at 6:46:19 a. m.

The lid of the catapult hatch was exploded at the altitude of 7 km at sea level.

4. Automatic release of the pilot-cosmonaut chute system:
   on "Vostok-3" at 6:39:59 a. m.,
   on "Vostok-4" at 6:46:21 a. m.
5. Spaceship-sputnik landing system was activated by automatic descent system:
   on "Vostok-3" at 6:40:12 a. m.,
   on "Vostok-4" at 6:46:34 a. m.
6. Landing of pilot-cosmonauts A. G. Nikolaev took place at 6:52:00 a. m. and P. R. Popovich at 6:59:00 a. m.
7. Landing of the spaceship-sputniks are:
   "Vostok-3" at 6:44:09 a. m.,
   "Vostok-4" at 6:50:37 a. m.

Engineer (V. V. Gubin)

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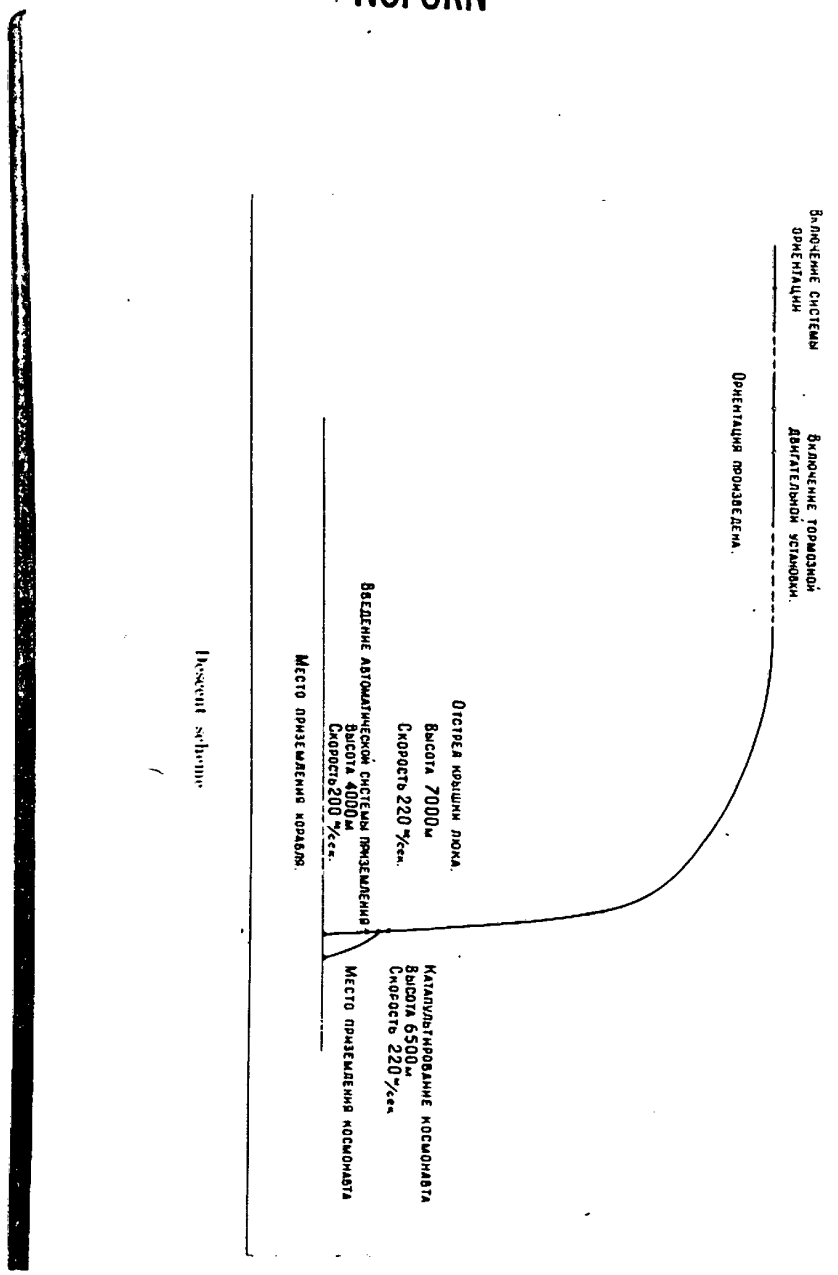
СХЕМА СПУСКА



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THE USSR TCHKALOV CENTRAL AERO CLUB

Group Flight Program

1. The "Vostok-3" spaceship take-off at 8.30.00 a. m. GMT, August 11, 1962.

2. The "Vostok-4" spaceship take-off at 8.00.00 a. m. GMT, August 12, 1962.

The launching time is determined more accurately by means of the real orbital parameters of the "Vostok-3" spaceship-sputnik.

After putting the "Vostok-4" spaceship into orbit the distance between the spaceships is to be approximately 5 km.

3. The flight plan: 64 orbits around the Earth for the "Vostok-3" spaceship, 48 orbits around the Earth for the "Vostok-4" spaceship.

4. The group landing of the spaceships is to be in Kasakhstan region in the latitude of 48° N. Lat. The flight being normal the landing is to be accomplished with the help of the automatic control system.

5. In the case of bad feeling of the cosmonaut or failing some onboard apparatus the spaceship may be landed ahead of the prescheduled time by means of manual controls or an automatic system.

The decision of landing before the appointed time using the manual controls is made after consulting the ground stations. In the case of communications failure the decision to land may be made by the cosmonaut independently.

6. In flight the cosmonauts maintain the radio communication on HF and UHF. The UHF communications are maintained within the operational range of the UHF stations.

During the first day the HF communications are to be maintained every half an hour Moscow time except for the period of sleeping, during next day every hour at 0 min. except for the period of sleeping and during the following day every hour at 00 min. except for the period of sleeping.

The communications between the "Vostok-3" and "Vostok-4" spaceships are to be maintained every half an hour at 00 min. (before the communication with the ground stations) and 30 min. (on the cosmonaut's call) Moscow time except for the period of sleeping.

The cosmonauts may use the broadcast radio set.

7. During the orbital flight the cosmonauts are to perform the following operations:

to make medical checking and monitor the indicators, to carry out vestibular and psychological tests, to make physical exercises and medical self-observations;

to control the spaceship's attitude by means of the manual control system, to estimate orientation time, fuel flow rate, time of the spaceship's quiescing, comfort of working conditions and the easiness to maintain the spaceship in the proper attitude.

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to conduct film shooting and scientific observations.

Subjects of the film and observations are selected at cosmonaut's discretion;

feeling fine once a day the cosmonaut is to leave the pressurizing system and to "float" during 50-60 min.; to define comfort and possibility of working with the instruments in zero-g conditions; to chose the most convenient position for making observations through the window;

to make entries in logbooks and record informations on tape recorders;

to monitor the functioning of the spaceship's system;

according to the instructions from the Earth the cosmonauts are to correct the onboard clock and to check the cabin-globe;

to eat food and drink water four times a day; to use the sanitary unit, to estimate the unusual manner in taking food;

to inform the ground stations of the functioning of the onboard apparatus after firing the retrorocket;

to catapult out of the cabins at the altitude of 6,5 km after the spaceship's decelerating in the lower atmosphere (during reentry) and to land by means of a chute.

The spaceships are to land without the pilots. In case the catapult fails the cosmonauts are to land in the cabin of the spaceships.

This flight plan was examined and adopted by the Presidium of the USSR Aero Sports Federation and the Sports Commission of the USSR Tekkalov Central Aero Club.

Executive secretary of Presidium of the USSR Aero Sports Federation (V. F. Naumkin)

Major pilot-cosmonaut (A. G. Nikolaev)

Lieutenant-Colonel pilot-cosmonaut (P. R. Popovich)

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Several times during the flight we manually controlled our spaceships and their attitude.

The flight programs have been carried out completely.

On August 15 descent was ordered. Up to the moment of catapulting we watched through the windows the heatshield burning during reentry.

We both had no difficulties while subjected to reentry g-loads. We landed by means of parachutes in the latitude of 48° N. Lat.

At the place of landing I was met by the representatives of groups of technical support, regimental rescue service, physicians and a sports commissar.

At the present time we feel fine and notice no ill effects.

Major, pilot-cosmonaut (A. G. Nikolaev)

Lieutenant-colonel, pilot-cosmonaut (P. R. Popovich)

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Pilot-cosmonauts of the USSR
major Andriyan Grigoryevich NIKOLAEV and
lieutenat-colonel Pavel Romanovich POPOVICH

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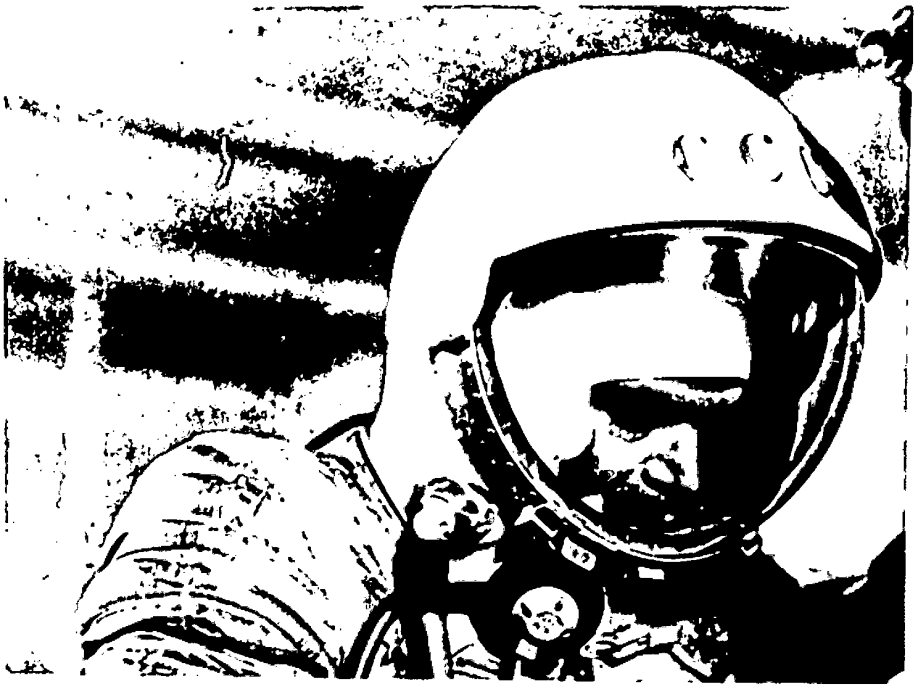

Pilot-cosmonaut A. G. NIKOLAEV
while checking up the pressure suit

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Control of helmet microphones in the pressure suit of pilot-cosmonaut P. R. POPOVICH

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Pilot cosmonauts A. G. NIKOLAEV and P. R. POPOVICH while trying on their pressure suits

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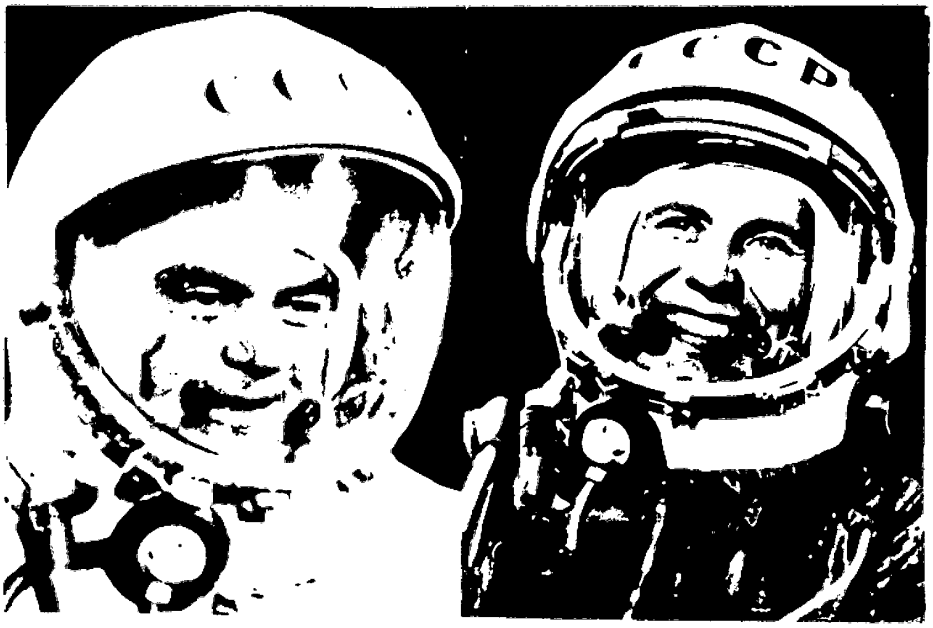

Prospective cosmonaut A. G. NIKOLAYEV and P. R. POPOVICH in pressure suits

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Pilot-cosmonaut A. G. NIKOLAEV on the way to the cosmodrome

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Pilot-cosmonaut P. R. POPOVICH
on the way to the cosmodrome

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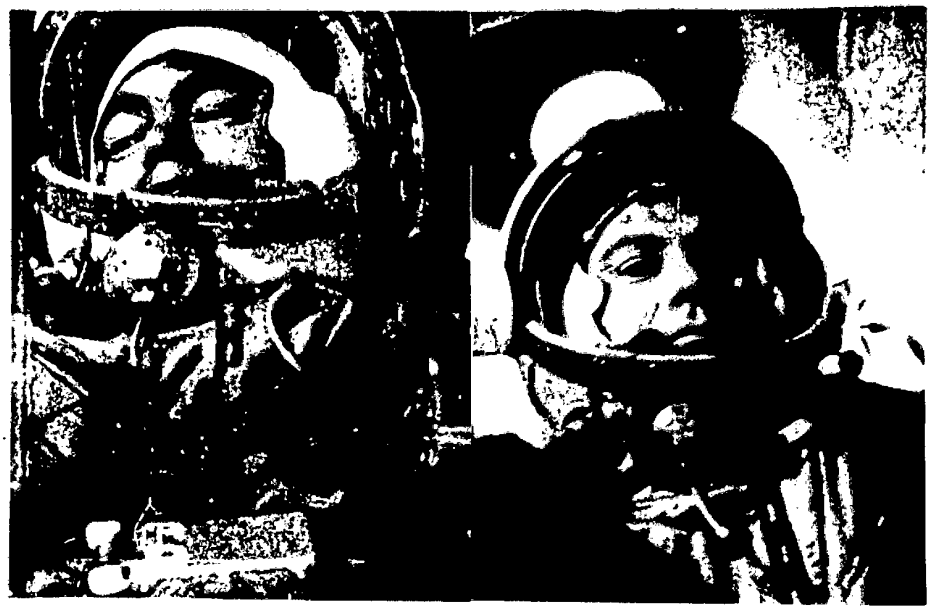

Pilot-cosmonauts A. G. NIKOLAEV and P. R. POPOVICH during the flight in the "Vostok-3" and "Vostok-4" spaceships

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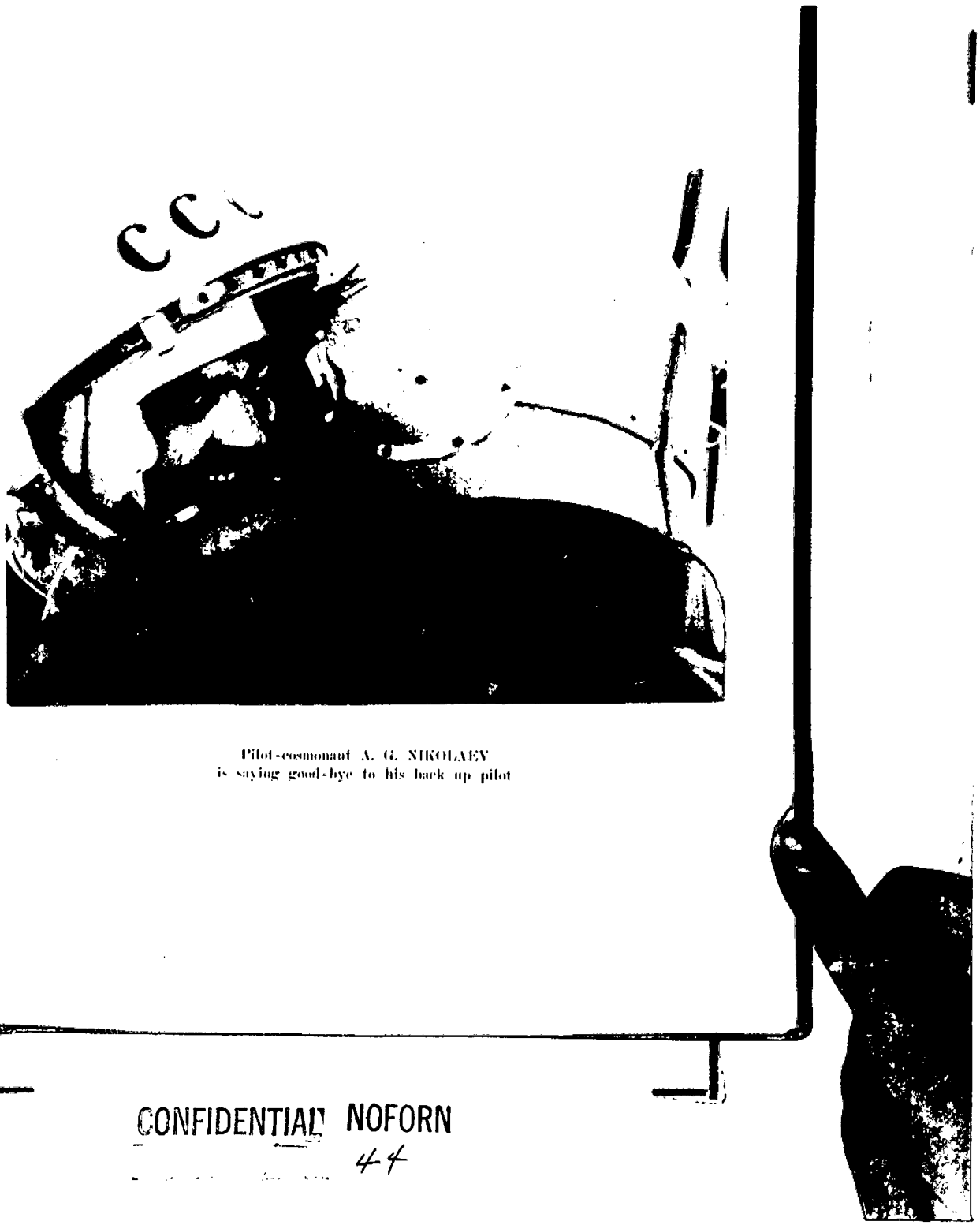

Pilot-cosmonaut A. G. NIKOLAEV
is saying good-bye to his back up pilot

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Pilot-cosmonauts A. G. NIKOLAEV and P. R. POPOVICH after landing

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PICTURES

taken with the movie camera
from the spaceship-sputniks "Vostok-3" and "Vostok-4"
by pilot-cosmonauts A. G. NIKOLAEV and P. R. POPOVICH,
11-15 August, 1962

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In terminator

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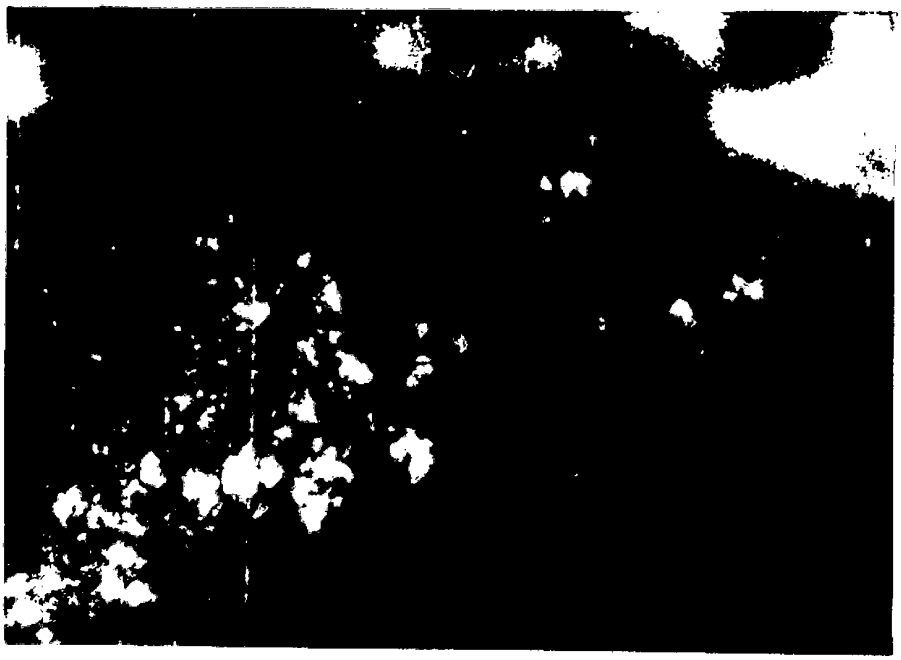

Sea coast

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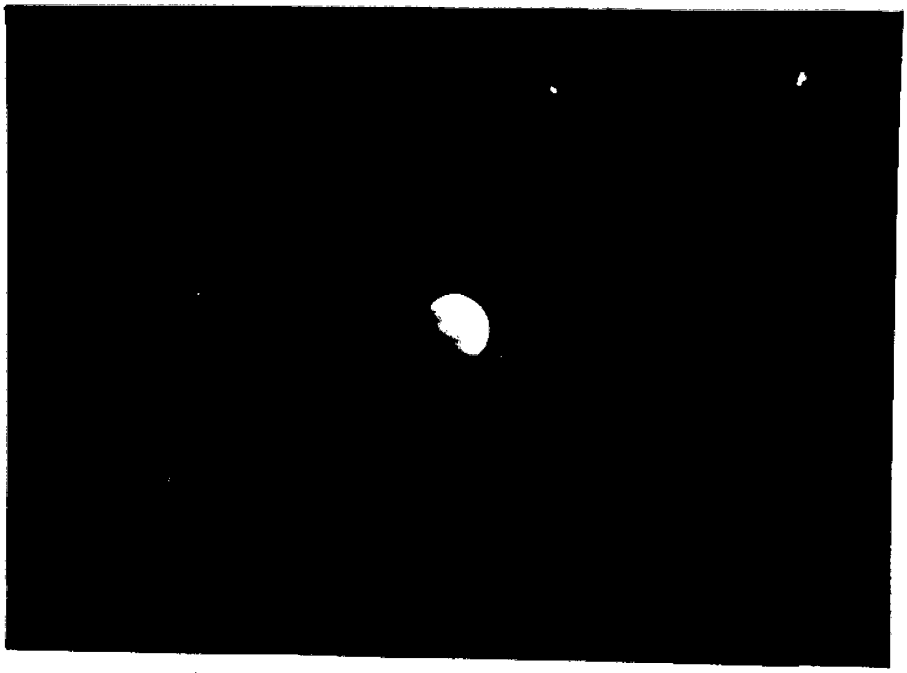

Moon

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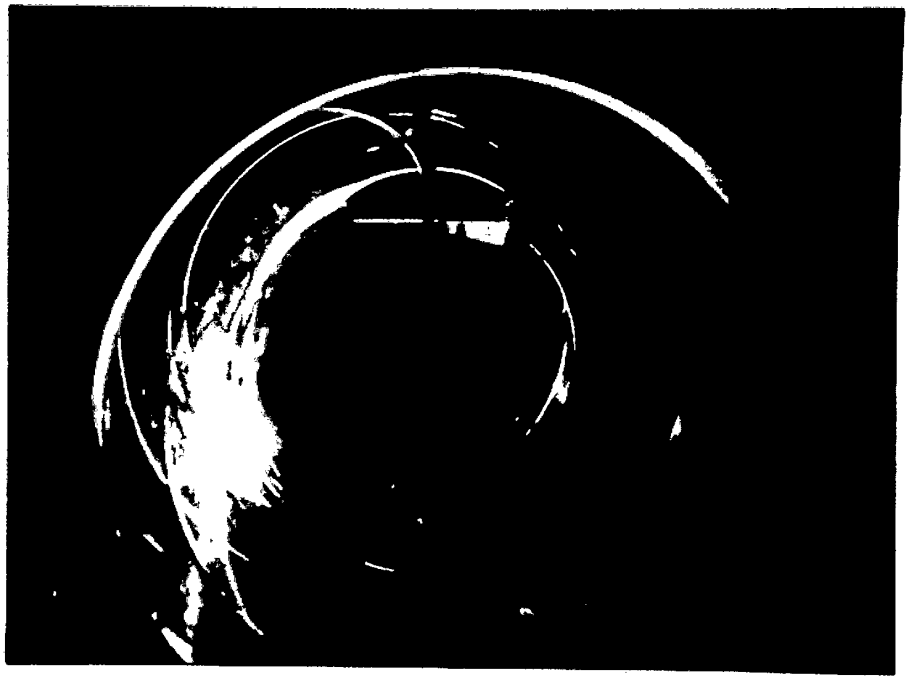

Sun taken through the optical orienting unit

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Photo taken through the optical orienting unit

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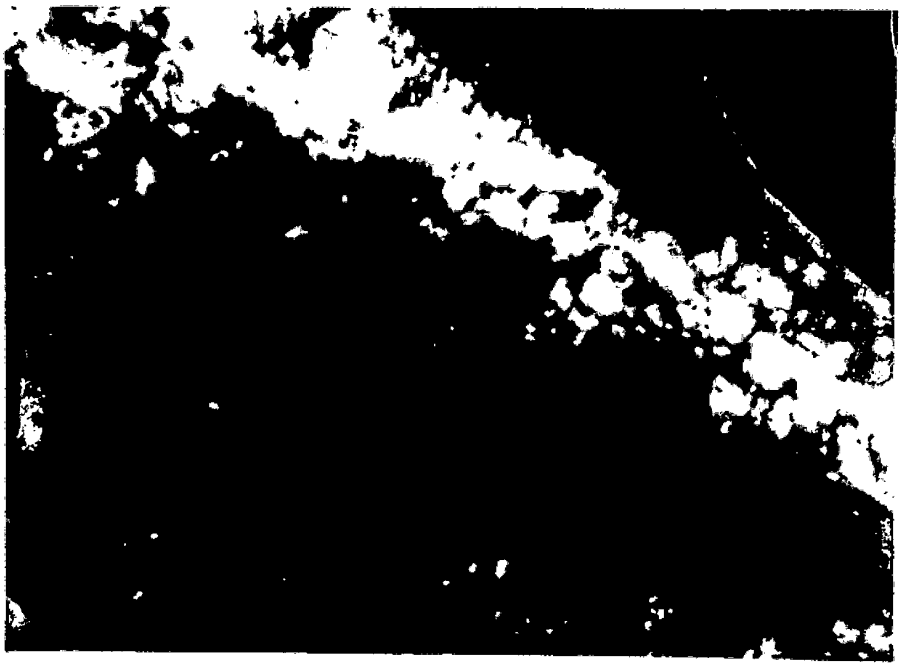

Sea coast

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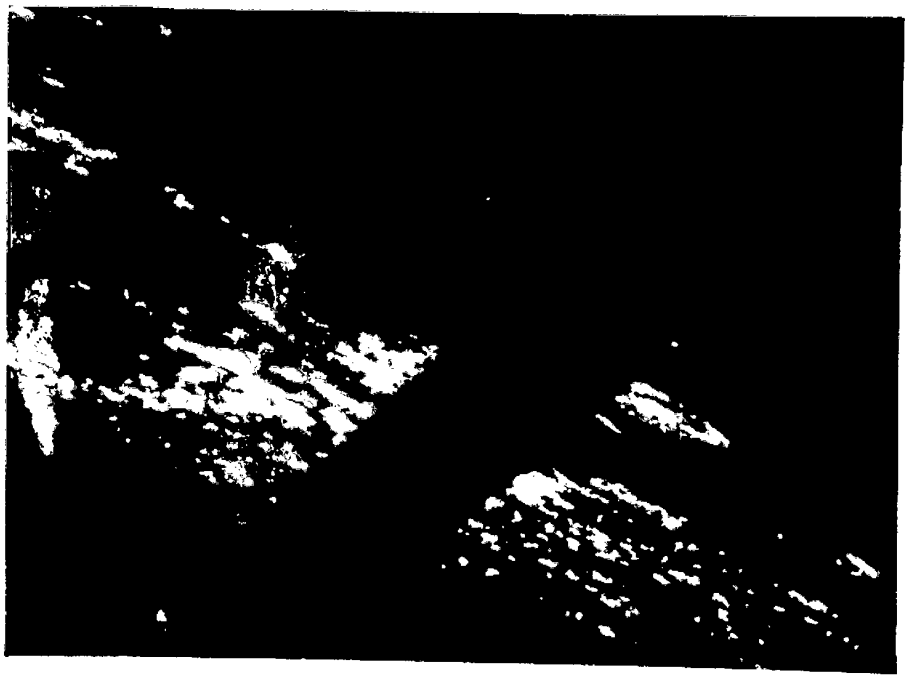

Clouds taken through the optical orienting unit

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THE UNION OF SOVIET SOCIALIST REPUBLICS
THE USSR TCHKALOV CENTRAL AERO CLUB

RECORDS FILE

ON THE SPACE FLIGHT
BY THE USSR CITIZEN
ANDRIYAN GRIGORYEVICH NIKOLAEV
IN THE "VOSTOK-3" SPACESHIP
August 11-15, 1962

MOSCOW
1962

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THE USSR TCHKALOV CENTRAL AERO CLUB

CARD OF GENERAL DATA

1. Records claimed: world record of space flight duration, world record of space flight distance, world record of space flight duration in the class of orbital flights, world record of space flight distance in the class of orbital flights.
2. Pilot: Andriyan Grigoryevich NIKOLAEV, sports certificate No. 3, dated February 20, 1960.
3. Citizenship: citizen of the USSR.
4. Type of vehicle: rocket.
5. Vehicle trade-mark: "Vostok-3".
6. Vehicle characteristics: the vehicle consists of a multistage carrier-rocket and a spaceship. The spaceship has a pilot's compartment with hatches and windows which houses the pilot and his outfit, an instrumentation compartment to place the control and communication gear in, and a compartment with the retrorocket.
7. Identifying marks (brief description): "USSR - VOSTOK-3".
8. Number and date of issue of spaceship book: Book No. 5, dated July 14, 1961.
9. Engines of vehicle:
   a) Type: Liquid-propellant rockets;
   b) Trade-mark: "Vostok";
   c) Power characteristics: Total maximum thrust of the rockets of all stages is 600,000 kg;
   d) Number of motors: 6.

I. G. Borisenko,
N. K. Nikitin,
sports commissars, the USSR Tchkalov Central Aero Club

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the weighing of the "Vostok-3" spaceship-sputnik

On the 10th of August, 1962, we, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, and Vladimir Ivanovich BODRIKOV and Nina Michaylovna TERESHENKOVA, calculating engineer, have drawn up a statement to the following:

On the 10th of August, 1962, we weighed the payload of 4722 kg mounted on the "Vostok-3" space rocket.

The payload consisted of the "Vostok-3" spaceship-sputnik with pilot-cosmonaut A. G. NIKOLAEV in his full space flight outfit to be put in orbit around the Earth.

The payload weight did not include the weight of the upper carrier-rocket stage.

Different elements of the "Vostok-3" spaceship-sputnik were weighed separately, they are as follows: pilot seat, instruments compartment, spaceship-sputnik cabin and retrorocket and spaceship-sputnik as a single unit, and pilot-cosmonaut A. G. NIKOLAEV in his full space flight outfit.

Weighing was made on the balance, type AR-10, No. 0741, with range of weighing from 500 kg to 10 tons.

Precision of weighing is illustrated by the following table.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

V. I. Bodrikov,
N. M. Tereshenkova,
calculating engineers

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TABLE

Precision of weighing on balance, type AIJ-10, No. 0741

WEIGHT (kg)	PRECISION (kg)
500	± 2.5
1000	± 2.5
2000	± 2.5
3000	± 3.0
4000	± 4.0
5000	± 5.0

The balance were checked in accordance with the instruction 49-57 of the Committee of standards, measures and measuring instruments at the Council of Ministry of the USSR, dated by the 26th of June, 1962.

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the launching of the carrier-rocket with the "Vostok-3" spaceship

On the 11th of August, 1962, we, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, bear witness to the launching of the rocket carrying the "Vostok-3" spaceship-sputnik with the identifying marks "USSR VOSTOK-3", piloted by cosmonaut Andriyan Grigoryevich NIKOLAEV.

The launching was made at 8:30:00 a. m. GMT from a cosmodrome near the station Baikonur.

The take-off of the rocket took place at 8:30:00 a. m. GMT.

Time was measured by the stop-watch, type "Primator", No. 386673, the accuracy of which is presented in the Appendix.

The geographical coordinates of the launching site are:

47°22'00" N. Lat.

65°29'00" E. Lon.

APPENDIX: The copy of the certificate No. 853 of the "Primator" stop-watch No. 386673.

I. G. Borisenko.

N. K. Nikitin.

sports commissars of the USSR Tchkalov Central Aero Club

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COPY

THE COMMITTEE
OF STANDARDS, MEASURES AND MEASURING INSTRUMENTS
AT THE COUNCIL OF MINISTRY OF THE USSR
The state measuring instruments laboratory, AURDI

CERTIFICATE No. 853
on the state test of stop-watch No. 386673

Range of measurements 60 sec. 60 min.

Type "Primator"

System

Manufacturer

Possession: the USSR Tchkalov Central Aero Club.

On the basis of state tests the instrument was adopted for use in the second class.

Laboratory Chief sign. (Shayko)

S. P.

State representative who made verification sign. (Menshova)

The 13th of March, 1962.

THE RESULTS OF STATE TESTS

Corrections for the stop-watch:

the dial upward, per 60 sec. 00
" " " per 30 min. +0.2
the head upward, per 60 sec. 00
" " " per 30 min. +1.1
The null position of the second needle 0.0 sec.
Temperature + 20° C

State representative who made verification sign. (Menshova)

The certificate is applied exactly.

The executive secretary of the sports commission of the USSR V. P. Tchkalov Central Aero Club (Golovanov N. M.)

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the defining of flight distance of the "Vostok-3" spaceship-sputnik, piloted by pilot-cosmonaut Andriyan Grigoryevich NIKOLAEV August 11-15, 1962

We, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, and Alexandra Ivanovna SRAGOVICH, department chief of the Coordinating Computation Centre, have drawn up the following statement:

On the basis of studying the results of data processing of the measurements taken during the "Vostok-3" spaceship flight on August 11-15, 1962, by the Coordinating Computation Centre, we have established the following.

The flight distance of the "Vostok-3" spaceship with pilot-cosmonaut Andriyan Grigoryevich NIKOLAEV on board amounts to 2639600 km.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

A. I. Sragovich,
department chief of the Coordinating Computation Centre

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on defining the flight duration of the "Vostok-3" spaceship piloted by cosmonaut Andriyan Grigoryevich NIKOLAEV August 11-15, 1962

We, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, have drawn up the following statement:

On the basis of the statements of launching and landing the "Vostok-3" spaceship and on the basis of studying the results of data processing of the measurements taken during the "Vostok-3" spaceship flight with pilot-cosmonaut Andriyan Grigoryevich NIKOLAEV, August 11-15, 1962, by the Coordinating Computation Centre, we have established that the total flight duration of pilot-cosmonaut Andriyan Grigoryevich NIKOLAEV from the moment of launching the rocket with the "Vostok-3" spaceship till the moment of jettisoning the pilot-cosmonaut from the "Vostok-3" spaceship is 94 hours, 00 minutes, 50 seconds.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

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THE COORDINATING COMPUTATION CENTRE

"MOSCOW COSMOS"

The "Vostok-3" space flight on August 11-15, 1962: Orbital data processing results; spaceship's flight range

Orbital data processing for the "Vostok-3" space flight on August 11-15, 1962, was carried out with the help of the M-20 and "Strela" electronic computers in accordance with the technique given below. The processing made it possible to find out the following parameters:

1. The minimum flight altitude above the Earth's surface during the first orbit:

$H_{min.}$ 180.7 km

Geodetic coordinates of the minimum altitude point are:

φ 44°23'30" N. Lat.

λ 39°26'30" E. Lon.

2. The maximum flight altitude above the Earth's surface during the first orbit:

$H_{max.}$ 234.6 km

The geodetic coordinates of the maximum altitude point are:

φ 64°57'00" S. Lat.

λ 73°34'00" W. Lon.

3. Geodetic coordinates, time (GMT) and flight altitude above the Earth's surface for the two points of the 47th orbit are:

φ_1 44°.4 N. Lat.	φ_2 51°.8 N. Lat.
λ_1 63°.9 E. Lon.	λ_2 176°.4 E. Lon.
H_1 178.0 km	H_2 181.0 km
t_1 8 hr. 07 min. 00 sec.	t_2 8 hr. 24 min. 00 sec.

4. Orbital parameters of the first orbit:

major semiaxis

a 6576500 m

eccentricity

e 0.00413

inclination

i 64°58'50"

perigee angular position

ω 74°35'20"

longitude of ascending node

Ω 122°38'20"

time of passing through perigee

τ 10 hr. 02 min. 33 sec.

time of passing through ascending node at the end of the turn

t 9 hr. 50 min. 15 sec.

period

T 88.330 min.

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5. "Vostok-3" velocity in the minimum and maximum altitude orbital point during the first orbit was 7.81 km sec. and 7.72 km sec., respectively.

"Vostok-3" velocity just before the retrofiring was 7.84 km sec.

6. "Vostok-3" orbital parameters evolution:

Parameters	11.VIII 1st orbit	12.VIII 17th orbit	13.VIII 33rd orbit	14.VIII 48th orbit	15.VIII 64th orbit
Period (min.)	88,330	88,260	88,180	88,084	87,972
Maximum altitude (km)	234.6	229.9	224.4	217.7	210.3
Minimum altitude (km)	180.7	178.0	175.2	172.0	168.4

The maximum flight range calculated on the basis of orbital data and with the use of the technique described below was found to be 2639600 km. This range was measured from the point of the cosmonaut's separation from "Vostok-3".

APPENDICES: 1. The technique of "Vostok-3" flight range calculation.
2. The technique of "Vostok-3" orbital parameters calculation.

Gparozhir *A. I. Stogorich,*
department chief, the
Coordinating Computation Center

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Technique of flight range determination of the "Vostok-3" spaceship

The flight range of the spaceship was calculated on M-20 and "Strela" electronic computers.

The flight range was defined as the sum of ranges of three flight phases:

$L = L_p + L_m + L_d$, where

- L — total flight range;
- L_p — flight range from the launching point to the point of cutting off the upper stage of the carrier-rocket;
- L_m — flight range from the point of cutting off the upper stage of the carrier-rocket to the point of firing the retrorocket;
- L_d — flight distance from the point of firing the retrorocket to the point of jettisonning the pilot-cosmonaut from the spaceship-sputnik.

Distance for each phase was estimated according to the formula:

$$L = \int_{t_a}^{t_b} \sqrt{V_x^2 + V_y^2 + V_z^2}\, dt, \text{ where}$$

- t_a, t_b — time of beginning and finishing the movement on a given phase;
- V_x, V_y, V_z — spaceship velocity vector components in the Cartesian coordinates;
- V_x, V_y, V_z — of the powered flight phase were estimated from the movement equations of the carrier-rocket of the "Vostok-3" spaceship. The time of the finishing was defined from the telemetering data recieved from the airborne instruments during this phase.

Besides, a correction was introduced into the actual coordinates of end powered flight phase in accordance with measurement data of spaceship movement parameters made by ground metering stations.

In the Earth-satellite orbital flight phase V_x, V_y, V_z were difined by solution of boundary problem of the point movement in the gravitation field of the rotating Earth.

The initial data for the boundary problem solution were the results of measurements of the spaceship movement parameters. This solution was carried out in accordance with the technique described below.

V_x, V_y, V_z for the phase from the movement of firing the retrorocket till jettisonning the pilot-cosmonaut from the spaceship-sputnik were estimated by solving the equations of motion according to the parameters of the initial phase and introducing corrections with respect to the actual coordinates the point of jettisonning the pilot-cosmonaut from the spaceship. The flight distance was defined in the coordinate system which moves in space together with the center of the Earth.

Grabar — *A. I. Seaparch,*
department chief of the Coordinating Computation Center

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The technique of "Vostok-3" orbital parameters calculation

The following basic assumptions on the spacecraft's motion were made to determine its orbital parameters. The satellite is treated as a mass point moving under the action of Earth's gravitational force and the air drag one.

Expanding the g-potential into spherical functions two components were taken into account, viz.: the uniform sphere potential and the term incorporating the Earth's flatness. Anomalies of the gravitational field were ignored.

The air drag deceleration was found by the formula

$$a = \kappa \rho v^2, \qquad (1)$$

where v — a module of the vector of the satellite relative velocity,

ρ — the air density at a given altitude,

κ — ballistic coefficient which value is determined by satellite weight and aerodynamic parameters.

The satellite is considered to move in $OXYZ$ Cartesian coordinates which are bounded rigidly to the rotating Earth. The origin of the coordinates is placed into the Earth's center, the OZ axis passes through the North Pole, the OX axis coincides with the Greenwich meridian and the OY axis is due East.

The satellite's orbital parameters were found on the basis of the processed tracking data by means of solving a boundary problem for the following system of the differential equations of motion:

$$\begin{aligned} \dot{V}_x &= -\kappa \rho V V_x - g_r \frac{x}{r} + g_m \frac{x}{r} \frac{z}{r} + 2\Omega_z V_y \\ \dot{V}_y &= -\kappa \rho V V_y - g_r \frac{y}{r} + g_m \frac{y}{r} \frac{z}{r} - 2\Omega_z V_x \\ \dot{V}_z &= -\kappa \rho V V_z - g_r \frac{z}{r} - g_m \frac{r_1}{r} \\ \dot{X} &= V_x, \qquad \dot{Y} = V_y, \qquad \dot{Z} = V_z \end{aligned} \qquad (2)$$

where $r = \sqrt{x^2 + y^2 + z^2}$, $r_1 = \sqrt{x^2 + y^2}$, $V = \sqrt{V_x^2 + V_y^2 + V_z^2}$,

g_r and g_m are radial and meridional components of the Earth's gravity, respectively (their positive values are to the center of the Earth for g_r and due south for g_m);

Ω_z — the Earth's angular velocity.

The initial data necessary to solve the boundary problem were the measured $t_i, r_i, \theta_i, \varphi_i$ ($i = 1, 2, \ldots, N$, where N is the total number of the measurements) and the calculated values of the initial motion parameters $\bar{q}_j^{(0)}$ ($j = 1, 2, \ldots, 6$) related to the moment $t_0 = t_1$ of the spacecraft insertion into orbit.

To determine t_i, r_i it was necessary to measure the range D_i from the tracking station (TS) to the satellite, the azimuth A_i of the "TS—satellite" line of sight and the tilt angle γ_i of this line. Measurements were carried out by the tracking stations situated on the territory of the USSR along the satellite track. The tracking stations were equipped with the radiotechnical systems, using the principle of active response from the satellite, and provided the necessary measuring precision.

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The measured data of the tracking stations were at the same time very accurately correlated with the standard time. To find the corrections δq_i to the initial conditions of motion the least squares method was used which allowed to calculate the orbital parameters to the highest precision possible.

In the case when the parameters D_i, A_i and γ_i were measured for non-corresponding points the following relations were accepted as temporary equations

$$\sum_{j=1}^{6} \frac{\partial r_i}{\partial q_j^{(m)}} p_i \delta q_j^{(m)} = \Delta r_i p_i, \qquad (i = 1, 2, \ldots, N_1). \qquad (3)$$

where $\frac{\partial r_i}{\partial q_j^{(m)}}$ is a partial derivative of the measured parameters with respect to initial motion conditions, $p_i = \frac{1}{\sigma(r_i)}$ is the "weight" of the i-th measurement, N_1 is the number of measurements (out of their total number N) used in a given calculation.

$$\Delta r_i = r_{i\,measured} - r_{i\,calculated}$$

Following some well known rules this system (3) of the temporary equations leads to the normal equations:

$$\sum_{m=1}^{6} a_{mm} \delta q_m^{(m)} = b_m, \qquad (m = 1, 2, \ldots, 6) \qquad (4)$$

Resolving these last equations one can find the corrections $\delta q_i^{(1)}$ $(i = 1, 2, \ldots, 6)$ for the initial motion conditions.

The boundary problem is solved by iteration technique. As a result refined initial motion conditions may be found by the formula:

$$q_m^{(m)} = \bar{q}_i^{(m)} + \sum_{j=1}^{l} \delta q_m^{(m)}, \qquad (j = 1, 2, \ldots, 6), \qquad (5)$$

where l is the number of iterations carried out until the complete convergence of the calculating process.

The refined initial motion conditions t_0, V_{x0}, V_{y0}, ..., Z_0 served as the basis for forecasting "Vostok-3" flight parameters. The latter is done by numerical integration of the motion equations (2) up to the time of retrofiring signal initiation and after that moment by numerical integration of the motion equations taking into consideration the retrofiring.

The boundary problem was solved and the forecasting was made with the help of the M-20 and "Strela" computers in the course of the spaceship's flight.

Later on to refine the orbital parameters tracking data of all the ground stations were treated completely and the precision of the basic orbital parameters was estimated.

Department chief,
Coordinating Computation Center Garokhr (A. I. Sergeyev)

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THE USSR TCHKALOV CENTRAL AERO CLUB

REPORT

on the "Vostok-3" spaceship construction and its special equipment

The "Vostok-3" spaceship is a guided rocket vehicle. Its construction is similar to that of "Vostok" and "Vostok-2" spaceships. The spaceship may be controlled both automatically and manually by the cosmonaut.

The spaceship consists of a pressurized cabin, which houses the cosmonaut, of an instrument compartment and a retrorocket compartment.

There is a special heat shield on the outside of the pilot's cabin that protects the cabin against the high temperature of reentry.

The cabin is equipped with two quickly opened hatches.

The cabin's shell has three windows for the cosmonaut to use for observations. The windows are provided with refractory glass designed to withstand the high temperature on the surface of the vehicle during reentry.

All the windows carry shutters which may be opened or closed either by an electrical drive or manually by the cosmonaut.

The spaceship's cabin houses a life-support system, a control system, food and water supplies, some of radio equipment, a binoculars for observations through the windows, TV-cameras, a cinematographic camera for shooting a film through the windows and a cinematographic camera for shooting a film inside the spaceship.

The instrument compartment contains some radio equipment, control equipment, a temperature control system and an electrical power system. In flight the cosmonaut is supported by a catapulted molded couch which is his working place and may serve as a means for leaving the cabin before landing. Supporting surfaces of the couch are fitted with soft plastic cushions.

The couch contains parachute systems providing the landing of the cosmonaut.

In case of water landing the cosmonaut may use a pneumatic liferaft inflated automatically. If for some reasons the cosmonaut cannot make use of the raft after water landing, a special device in the pressure suit keeps the cosmonaut lying on his back above the surface.

During the orbital flight ventilation of the cosmonaut's pressure suit is performed with the air taken out of the cabin. In case of the cabin's decompression the suit is automatically pressurized. In this case the reserves of the onboard compressed oxygen and air provide the oxygen supply to the cosmonaut for breathing and the air for ventilating the space suit. In case of decompression of the cabin the oxygen and air reserves allow the cosmonaut enough time to establish radio contact with the ground, to choose a place for landing and to descend.

The manual flight and descent control system allow the cosmonaut manually control the vehicle's attitude in space and to land the ship in the desired area.

The attitude control system provides a proper attitude of the vehicle before firing the retrorocket. This system is divided operationally into an automatic one and a manual one.

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An optical orienting unit used by the cosmonaut to find out the flight direction and the local vertical is mounted on one of the cabin's windows.

The retrorocket with the control system is designed to change the magnitude and direction of the spaceship's velocity vector to transfer it from the Earth's satellite orbit to a descending trajectory.

The retrorocket may be activated both automatically and at pilot's desire by means of a switch on the instrument panel.

The flight control system provides automatic control of onboard instruments according to a prescribed programme. The spaceship is equipped with radio equipment for two-way communication of the cosmonaut and ground stations during prelaunch operations, powered flight and orbital flight.

The radio equipment includes two short-wave receivers and two short-wave transmitters, an ultrashort-wave receiver and transmitter, a tape recorder, a broadcast receiver and electroacoustic equipment.

The frequencies of the onboard transmitters are 18, 035; 20, 006 and 144 150 megacycles per second.

The type of communication is chosen by the pilot switching on the proper radio system.

The tape recorder is switched on either automatically by the cosmonaut's voice sound or manually.

Tape recorded data are radioed to the ground at an increased speed by the command from a receiving station when the spaceship is over it. Orbit radio control of the spaceship equipment for powered and orbital phases consists of receiving and transmitting signal forming instruments and an antenna system.

The TV-system is designed for watching the cosmonaut and receiving objective data on his state, behaviour, movement coordination while performing various operations.

Instruments for monitoring and recording physiological functions of the cosmonaut in flight, viz.: pulse rate, respiration, etc., allow to conduct continuous observations of the cosmonaut's state.

Radio and telemetering equipment, self-contained regeneration system and sensors provide monitoring and recording of the onboard instruments performance in flight. The spaceship carries the "Signal" radio system operating on the frequencies of 19.995 and 19.990 megacycles per second.

To maintain the basic microclimate parameters in the cabin within the limits close to normal a conditioning system is used, which absorbs carbon dioxide and moisture and supplies the necessary amount of oxygen for pilot's respiration. The oxygen flow rate in the system is controlled automatically.

The conditioning system also absorbs the harmful contaminations which result from human life activity and instrument operation.

Normal cabin pressure is maintained with the help of a pressure control system.

The food and water supply systems provide the pilot with food and water throughout flight.

The pilot has a four-meal diet.

A special sanitary unit is designed for collection of liquid and solid excretion products.

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The automatic temperature control system is installed aboard the spaceship to maintain the cosmonaut's state regime within given limits.

The system consists of two loops: an air-loop opened into the cabin and a liquid one connected with a radiating heat source, mounted on the instrument compartment. Both loops are connected to an air-liquid heat exchanger, located in the cabin.

Such a system ensures the maintenance and control of the cabin temperature by the cosmonaut within the range of +12 to +27 °C.

The cabin light system includes the "on-duty" illumination and the operational one. Illumination is controlled by switches on the instrumentation panel and may be turned on and off by the pilot.

The system provides illumination from 5 to 70 luxes. The landing system ensures a safe landing of the spaceship and the pilot during the last phase of descent.

A device for determining by the pilot the spaceship's position in orbit and geographic coordinates of the expected landing point is made in the form of a globe scaled down to 100,000,000 times.

The globe rotates simultaneously around two axes. Rotation around one axis corresponds to the Earth's rotation taking into account corrections for the precession of the spaceship's orbit. Rotation around the second axis corresponds to the orbital movement of the spaceship.

Thus every moment under the cross lines marked on the face glass of the instrument a place appears over which the spaceship is flying at this moment. Indication of the expected landing point is carried out by turning the globe about the angle corresponding to the angle of descent from the point of firing the retrorocket to the landing point.

The globe design permits to make necessary corrections to the instrument's operations in accordance with the real orbital parameters.

In contrast to the "Vostok" and "Vostok-2" spaceships the "Vostok-3" spaceship has the following modifications.

The spaceship carries an advanced TV-system to improve the quality of the TV-images sent from the ship. The water supply system is modified. To enlarge the volume of information on the cosmonaut's state additional instruments for measuring pilot's skin-galvanic reflexes, taking electrical encephalogram and electrocardiogram and transmitting them to the ground are set aboard the spaceship.

Besides that, additional instruments for recording the ionizing radiation dose are used.

The pilot's instrumentation panel is also improved and it allows the cosmonaut to better control the spaceship's systems.

The couch, pressure suit and parachute system of the cosmonaut are modified too to increase their reliability and accessibility.

Improvements were introduced into onboard radio systems to provide communication capability between the "Vostok-3" and "Vostok-4" spaceships.

In addition to the modifications mentioned above some improvements were made as to the spaceship structure to increase the strength of some of its components and reliability of the structure as a whole.

Kamanin F. Konstantinov,
engineer

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THE USSR TCHKALOV CENTRAL AERO CLUB

Telemetry data from the "Vostok-3" spaceship

During the flight of the "Vostok-3" spaceship piloted by the Soviet cosmonaut Andriyan Grigoryevich NIKOLAEV telemetery data were to be received pertaining to the following areas:

medical monitoring of the cosmonauts state;

cabin environmental conditions monitoring;

monitoring of the manual control system;

monitoring of the spaceship's attitude control system;

monitoring of the voice communication system;

monitoring of various instrumentation systems and the spaceship's structural components;

measuring of the space radiation level inside the spaceship's cabin.

The recorded data from the corresponding sensors and instruments were transmitted by onboard transmitters during both powered and orbital flight phases and were received by ground tracking stations.

During the reentry and landing phases data were recorded by onboard selfcontained memory devices.

The data were received during period of radio contact with the spaceship beginning from the take-off and to the landing.

Every period of radio contact lasted 5 to 20 min. and the total time of telemetering contact during the "Vostok-3" spaceship's four days flight ammounts to some 550 minutes.

Medical monitoring of the cosmonaut's physiological state was carried out with the help of the telemetering system on the basis of the following biological characteristics:

electrocardiogram;

pneumogram;

electroencephalogram;

electrooculograms;

skin galvanic reflex.

At the same time a special radio-transmitter continuously monitored the cosmonaut's pulse rate.

Copies of portions of the cosmonaut A. G. NIKOLAEV's electrocardiogram, electroencephalogram, electrooculogram and pneumogram are given below.

The mean values of the pilot's pulse and breathing rates on the various flight phases are listed in table 1.

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Table 1

Flight phases	Pulse rate beats/min	Breathing rate /min
PRE-LAUNCH PHASE	111	11
POWERED FLIGHT PHASE		
at the beginning of the powered flight	130	14
at the end of the powered flight	112	15
ORBITAL FLIGHT		
1st orbit	127	14
2nd "	100	11
18th "	79	21
34th "	52	18
50th "	72	14
63rd "	67	9
BRAKING	87	14
REENTRY	102	12

The analyses of the medical telemetery data has shown, that NIKOLAEV'S basic physiologycal responces on every stage of his four days space flight were within the same limits as in normal ground conditions and during training.

The state of respiratory and blood circulation systems, vestibular system and the central nervous system was normal.

Apart from the medical monitoring the TM-systems recorded the readings of the following sensors, mounted inside the cabin:

temperature sensor;

pressure sensors;

humidity sensor;

gas composition sensor; as well as the readings of the sensors monitoring the systems of:

thermoregulation;

air conditioning;

air regeneration;

sun orientation;

ship control and the radiation level measuring system.

The processed telemetery data in the areas mentioned above are given in table 2.

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Table 2.

№ №	Characteristics	Units of measure	Phases: launch and orbital flight	Phases: descent	Precision
1	Air pressure in cabin	mm Hg.	765	765 ; 755 / 760 ; 500	± 10 mm
2	Pressure in spacesuit	mm Hg.	765	765 ; 755	± 10 mm
3	The air temperature in cabin	C	20	26 ; 13	± 1 °C
4	Cabin air composition: oxygen	%	21 ; 22	22 ; 25	25	± 2%
	Carbon dioxide		0,3	0,3 ; 0,5		0,1%
5	Cabin humidity	%	60 ; 65	70 ; 50		± 5%
6	Radiation level	mrad day		12		± 1

Telemetery data processing was performed with the use of calibration data.

The sensores were calibrated during the plant and complex tests of "Vostok-3" together with cabin telemetery systems.

Some of the calibration plots are given below.

S. M. Ivanov,
engineer

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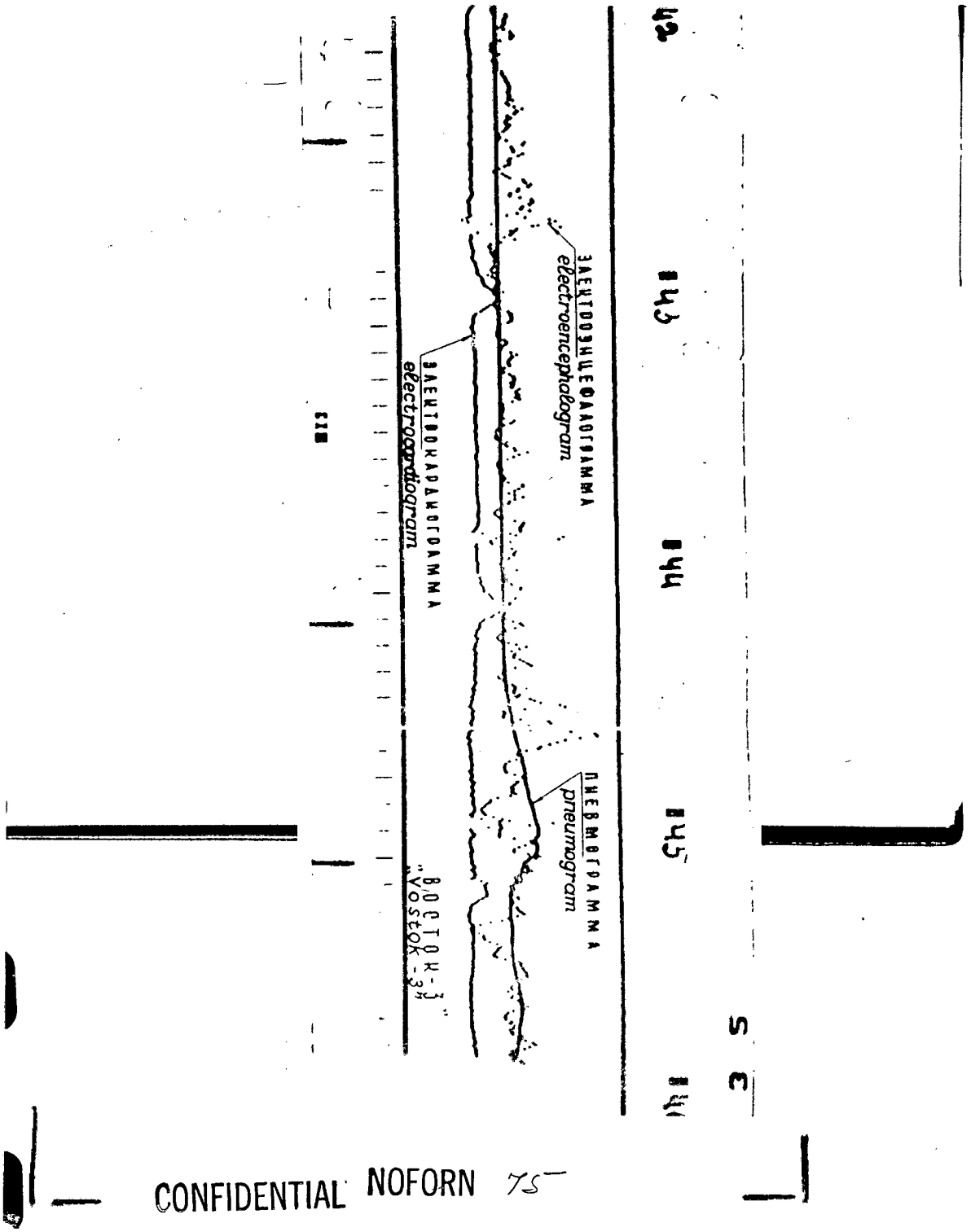

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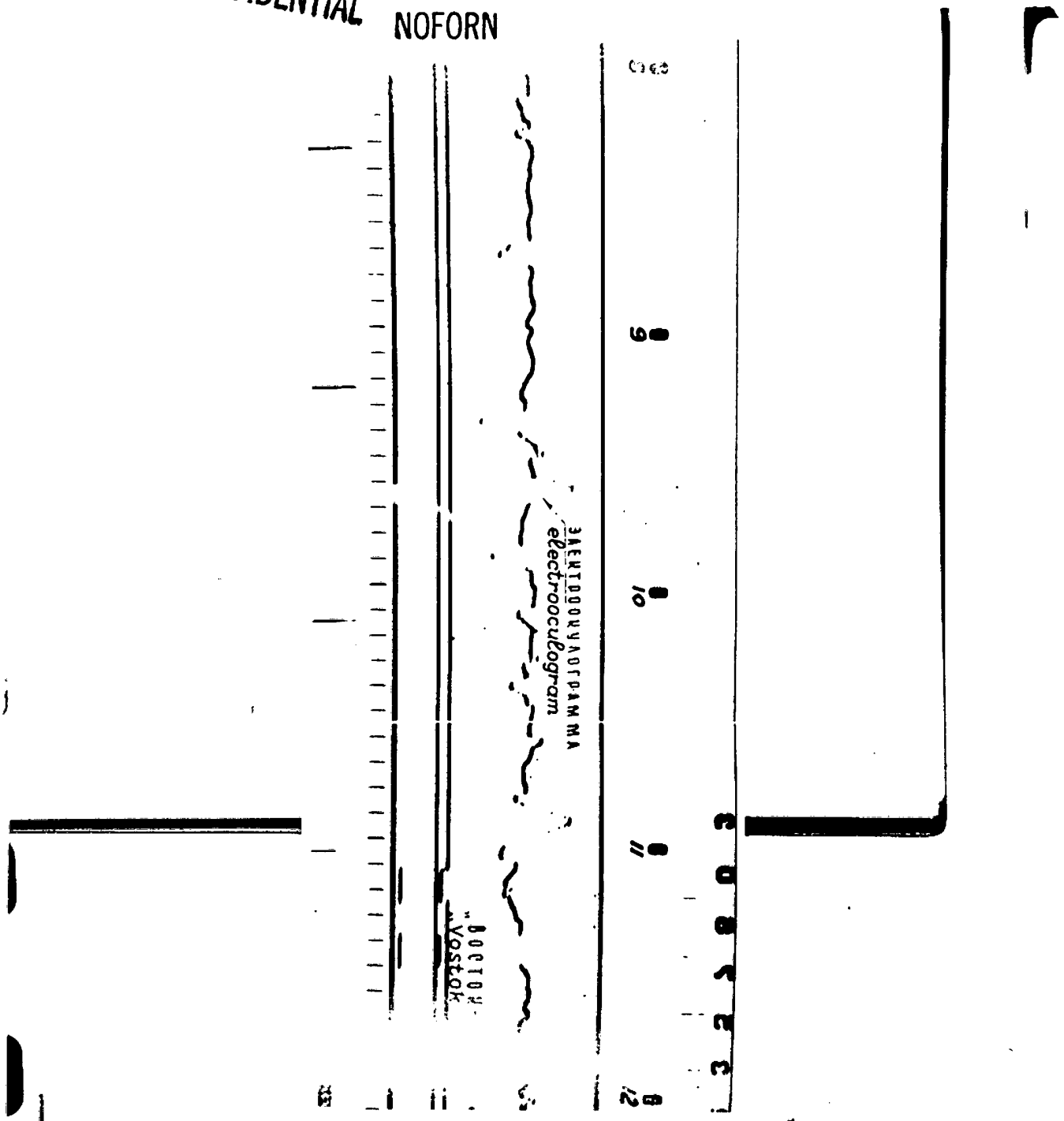

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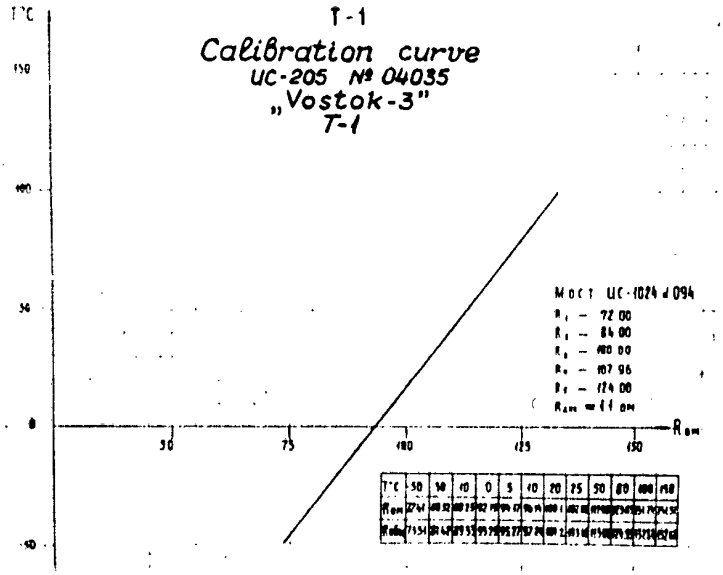
ТАРИРОВОЧНЫЙ ГРАФИК

УС-205 № 04035

„ВОСТОК-3"

Т-1

Calibration curve
УС-205 № 04035
„Vostok-3"
Т-1



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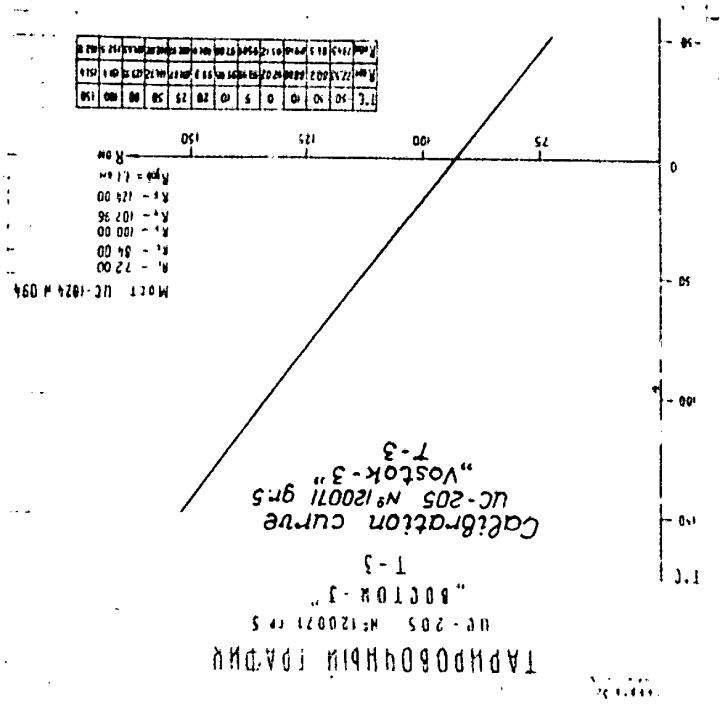

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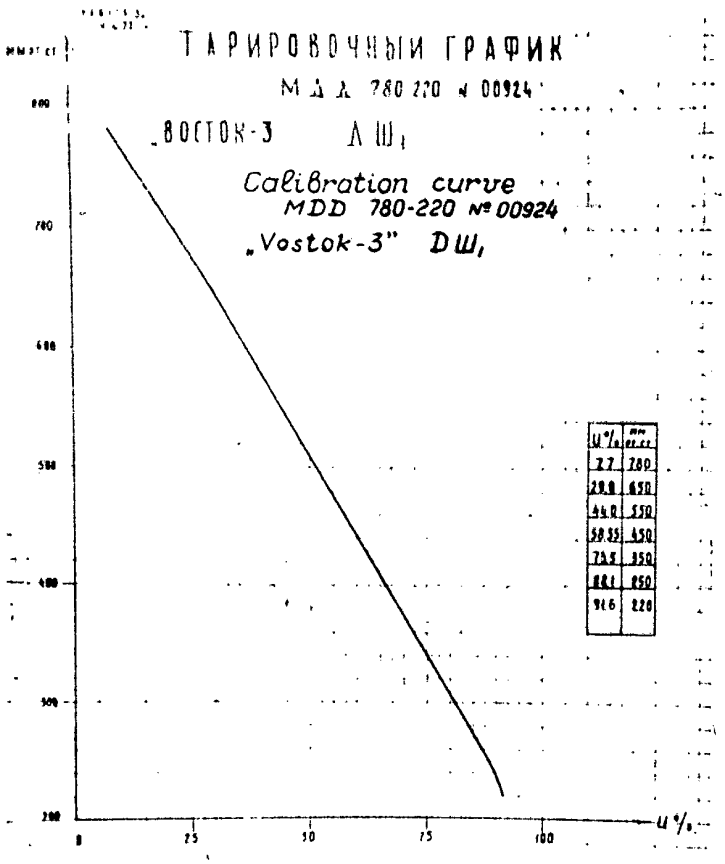

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THE USSR FEDERATION CENTRAL AERO CLUB

Brief description of measuring instruments and accuracy of measurements. Calibration curves.

Measurements were taken by the tracking stations located along the satellite ground track on the territory of the USSR.

The tracking stations were equipped with radars operating in the regime of active response from the satellite.

The measurements included slant range D_i from the tracking stations (TS) to the satellite, azimuths A_i of the lines of sight "TS-satellite", and tilt angles γ_i of this line.

The measurements of slant range were carried out by defining time intervals between the moment when the signal was sent and the moment of its reception with the subsequent presentation of these periods in a binary code.

While carrying out the measurements corrections to signals delay in ground and airborne instruments were taken into account. Corrections were found by means of special calibration of the measuring instruments during the prelaunch countdown (see Appendix). Corrections for radar measurements were also made during the intervals between the periods of communications with the satellite.

The azimuth A_i and the angle γ_i were defined with the help of track antennas and "shaft-figure" converters in the binary code.

The airborne instruments provided simultaneous communications with several ground stations in the regime of active response.

The airborne instruments were switched on for a limited period of time during the flight of the sputnik over the territory of the Soviet Union where the tracking stations were located.

The results of the measurements were correlated to the standard time by means of highstable generators synchronized by radio with the accuracy of 1° in phase.

The precision of time correlation of measured data at all tracking stations was higher than 10 sec. The radar information from each tracking site was automatically supplied through communication lines to the Coordinating Computation Centre and was simultaneously processed on M-20 and "Strela" type electron computers.

MEASURING INSTRUMENTS CHARACTERISTICS

Short wave ground radar stations.

The quality of measuring the slant range (D_i) is 25 meters not taking into account the instability of propagation velocity of electromagnetic oscillations.

The precision of measuring the angular position is not higher than 1.5'.

Error values comprise calibration mistakes, viz.: less than 3 meters for range and 10" for azimuth and elevation.

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CALIBRATION TECHNIQUE

a) Of ground stations

Comparison of calibration range with geodetic [illegible] sion of 0.2 meter

b) Of reference device

Comparison between the radio range measured [illegible] station to the satellite antennas, when the satellite is in the [illegible] and the geodetic range between these objects [illegible] radar stations, measured according to the item "a"

c) Calibration of delay time in measuring [illegible]

The change of signal level causes variations in the delay [illegible] measuring instruments, which leads to errors in range data.

Since these errors were neglected while measuring the "Vesta" [illegible] tes the values of these errors must be provided to be [illegible].

For this purpose appropriate calibrations were made [illegible] values of the mentioned errors.

Calibration was carried out by recording signal delay time with [illegible] signal intensity. The recording of the variations in the delay time [illegible] the measuring systems versus signal intensity (in strength) with [illegible] 40 decibel are presented in the calibration diagram.

The delay-time variations from the mean value are plotted [illegible] axis, the variations of signal intensity are plotted along the [illegible] axis.

Calibration levels of delay time in microseconds ([illegible] are given in the beginning of the plot.

The calibration confirmed the possibility of neglecting [illegible] signal delay-time instability in the range channel.

The maximum error was less than [illegible] microsecond ([illegible])

Engineer [illegible]

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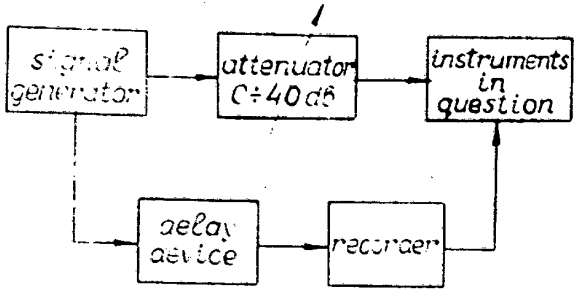
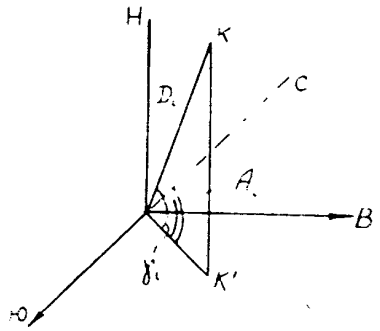
Delay time calibration

-UN





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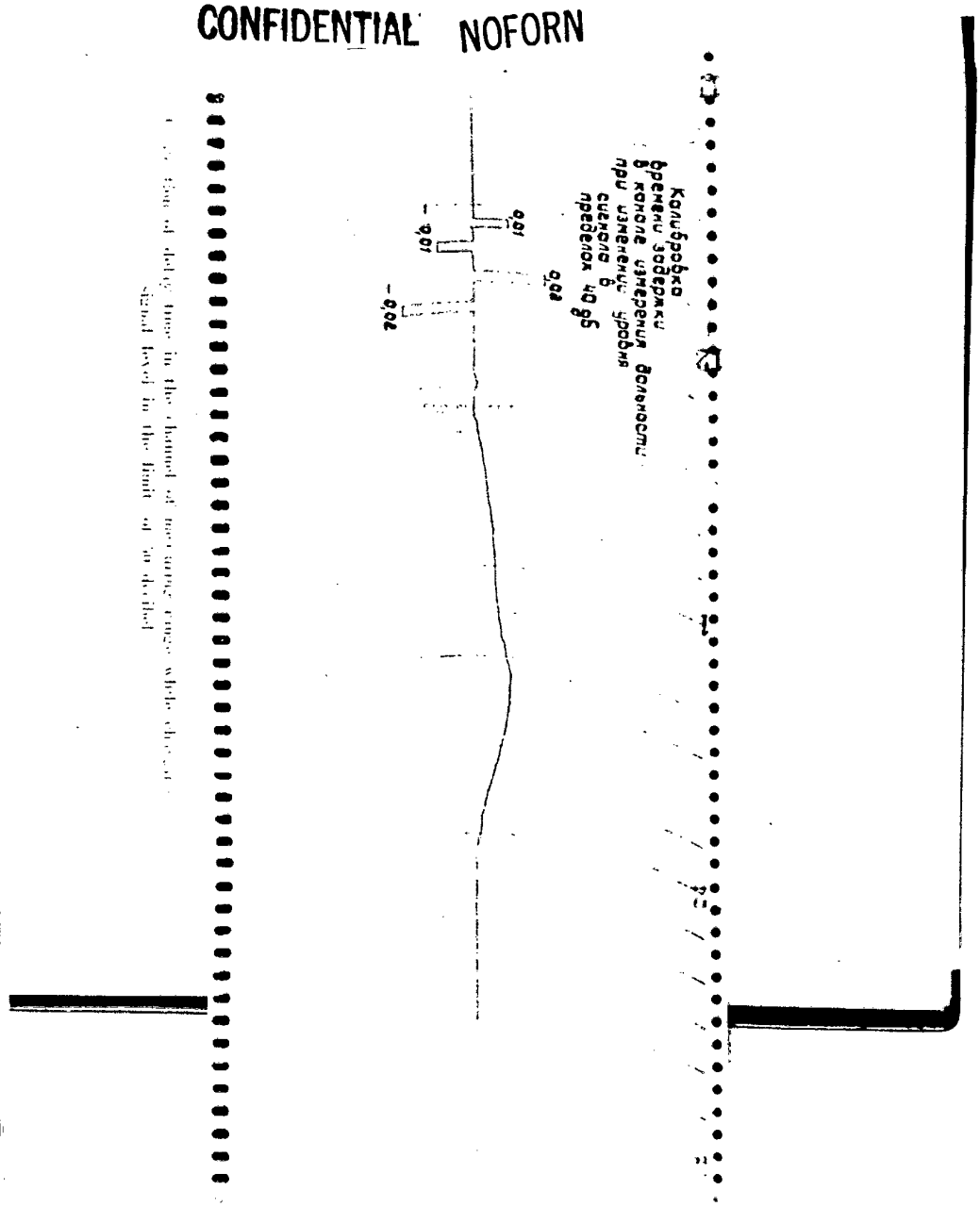

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THE USSR TCHKALOV CENTRAL AERO CLUB

DESCENT SCHEDULE

(GMT)

1. At 5:47:45 a. m. the automatic descent system switched on the spaceship attitude control system.

2. At 6:24:08 a. m. the automatic descent system activated the retrorocket.

3. At 6:39:57 a. m. the automatic descent system exploded the lid of the catapult hatch and in 2 seconds the chute system was automatically released.

The lid of the catapult hatch was exploded at the altitude of 7 km.

4. At 6:40:42 a. m. the automatic descent system switched on the ship's landing system.

5. At 6:52:00 a. m. the landing of the pilot-cosmonaut took place.

6. At 6:44:09 a. m. the landing of the spaceship-sputnik took place.

Engineer В. Галин *(V. V. Galin)*

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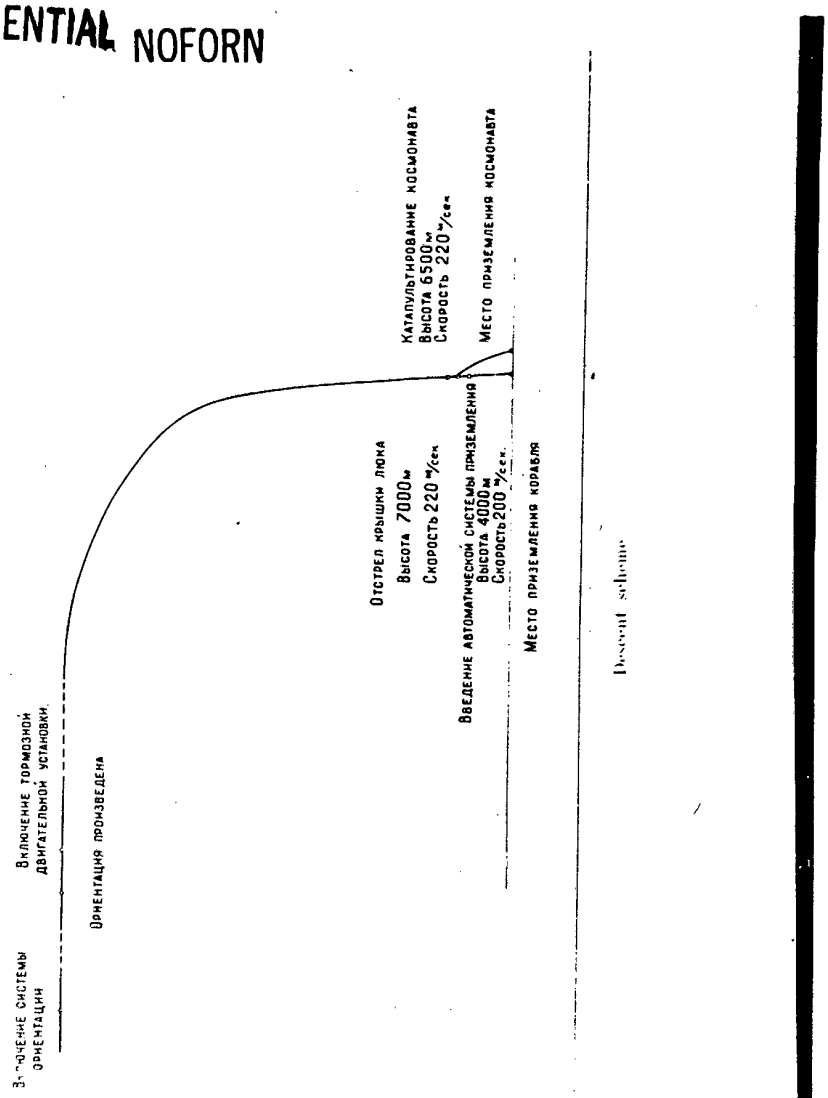
СХЕМА СПУСКА



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THE USSR TCHKALOV CENTRAL AERO CLUB

FLIGHT PROGRAM

1. Spaceship take off at 8:30:00 a. m. GMT, on August 11, 1962.

2. Flight plan: 64 orbits around the Earth with landing on the territory of the USSR in the latitude of 48° N. lat. The flight being normal the landing is accomplished with the help of the automatic control system.

3. In the case of bad feeling of the cosmonaut or failing some onboard apparatus the spaceship may be landed ahead of the prescheduled time by means of manual controls or an automatic system.

The decision of landing before the appointed time using the manual controls is made after the consulting the ground stations.

4. In flight the cosmonaut maintains radio communications on HF and UHF. The UHF communications are maintained within the operational range of the UHF stations. During the first day the HF communications are to be maintained every half an hour besides the period of sleeping; during the second, third and forth days every hour at 0 min. Moscow time except for the period of sleeping.

The communications with the "Vostok-4" spaceship are maintained by the HF radio channel every half an hour at 0 min. during the second, third and forth days of the flight (before the communication with the ground stations) and 30 min. (on cosmonaut's call of the "Vostok-4" spaceship) Moscow time besides the period of sleeping.

5. The cosmonaut may use the broadcast radio set.

During the flight the cosmonaut is to perform the following operations:

to make medical checks and monitor the indicators, to carry out vestibular and psychological tests, to make physical exercises and medical self-observations;

to carry out the spaceship's attitude by means of the manual control system, to estimate the orientation time, fuel flow rate, the time of the spaceship's quieseing, comfort of working conditions and the easiness to maintain the spaceship in the proper attitude;

to shoot a film and make the scientific observations; subjects of the film and observations are selected at cosmonaut's discretion;

to take a picture and make observations during the putting of the spaceship into orbit.

During rest the cosmonaut is to leave the restraining system once a day [illegible] "Vostok-4" during 30-60 min., to define comfort and possibility of working

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Once every 24 hours during the flight I [illegible] my couch and continued to work in the cabin. I [illegible] took some pictures of the Moon, have made [illegible] and made records on the tape-recorder.

Throughout the flight climatic conditions inside the cabin [illegible] cabin pressure equalled to that at sea-level, the temperature was [illegible] composition usual for the Earth's conditions. The air conditioning system [illegible] very well.

When necessary I controlled the cabin temperature myself.

The flight program has been carried out completely. In the beginning [illegible] in accordance with the flight program an automatic system [illegible] the spacecraft within the desired area was [illegible].

After the spacecraft had been properly oriented the retro-rocket was fired and the craft went along the descent trajectory. At first g-load was small, then it began to increase very rapidly. Soon after the region of high [illegible] and peak g-load had been passed the landing system was activated.

In this flight I used the landing system which envisages the separation of the couch with the cosmonaut from the spacecraft.

Not long before landing the couch with me separated from the craft, then the parachute system was activated with the help of which I landed. The spacecraft landed nearby. It was at 6:52 a. m. GMT, August 15, 1962. At the place of landing I was met by the representatives of groups of technical support, regimental rescue service, physicians and a sports commissar.

At the present time I feel fine and notice no ill effects or changes in my organism.

Major, pilot-cosmonaut
A. G. Nikolaev

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Major, pilot-cosmonaut of the USSR
Andrian Grigorevich NIKOLAEV

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Pilot-cosmonaut A. G. NIKOLAYEV
in his pressure suit

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Pilot-cosmonaut A. G. NIKOLAYEV
on the way to the spacecraft

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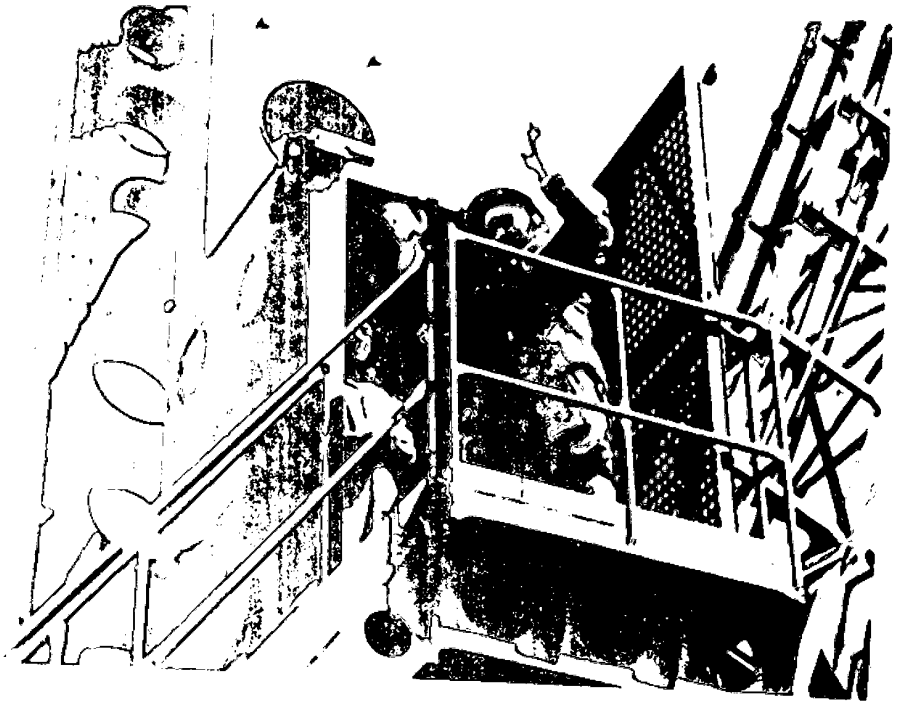

Pilot cosmonaut A. G. NIKOLAEV
before the entry into the «Vostok-3» spaceship

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[illegible] aboard A. G. NIKOLAEV region of landing

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PICTURES

taken with the movie camera
from the "Vostok-3" spaceship-sputnik
by pilot-cosmonaut A. G. NIKOLAEV
11-15 August, 1962

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[illegible] taken through the optical orienting unit

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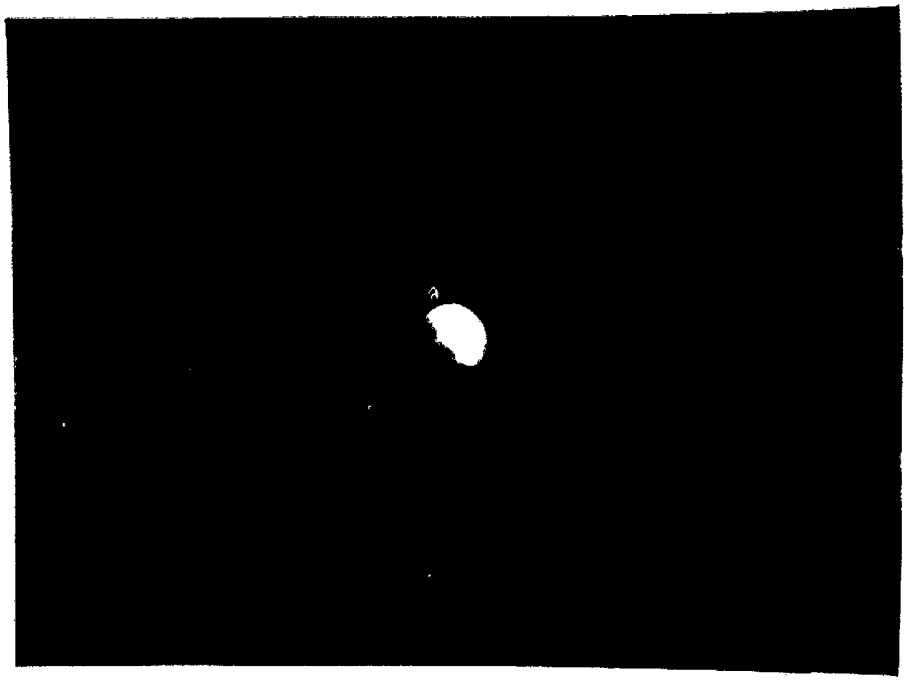

Moon

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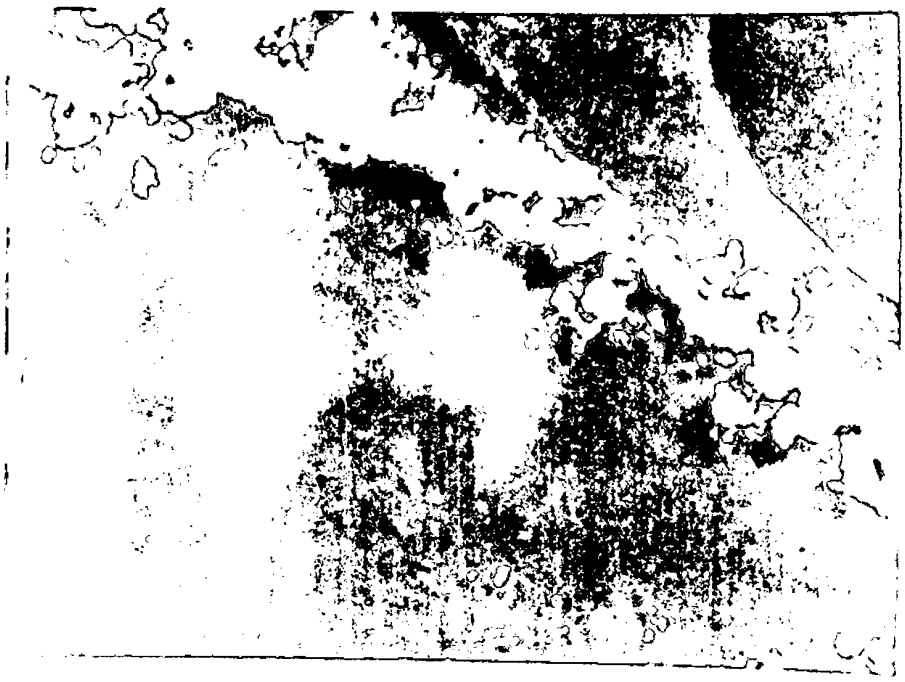

[illegible] through the side window

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Photo taken through the optical orienting unit

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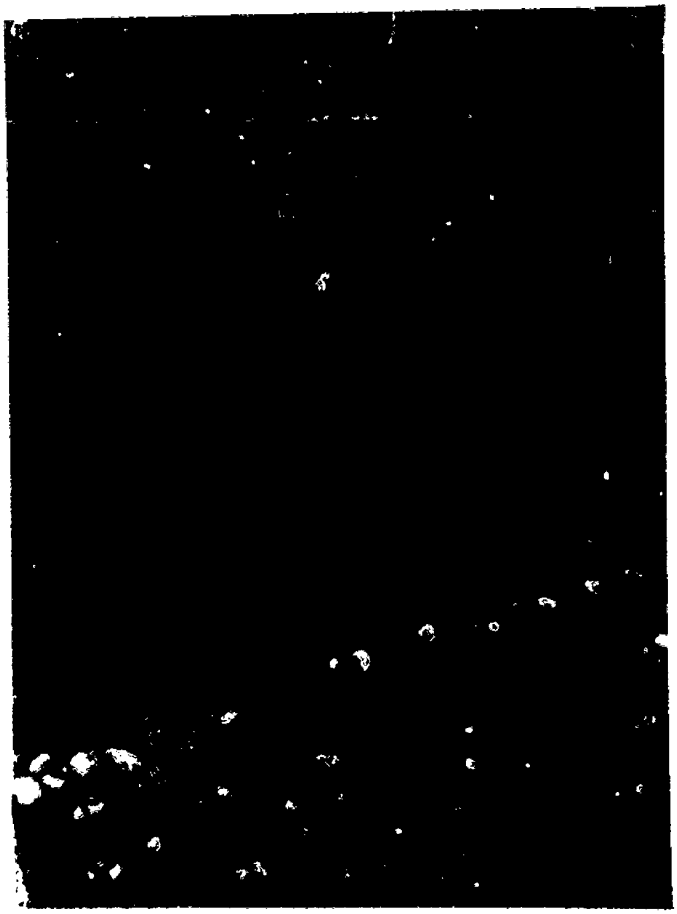

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THE UNION OF SOVIET SOCIALIST REPUBLICS
THE USSR DOSAAF CENTRAL AERO CLUB

ACHIEVEMENTS FILE

ON THE OUTSTANDING SPACE FLIGHT
BY THE USSR CITIZEN
PAVEL POMANOVICH POPOVICH
IN THE "VOSTOK-4" SPACESHIP
August 12-15, 1962

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on weighing the "Vostok-4" spaceship-sputnik

On the 10th of August, 1962, we, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, Vladimir Ivanovich BODRIKOV and Nina Michailovna TURUSHENKOVA, calculating engineers, draw up a statement to the following fact:

On the 10th of August, 1962, we weighed the payload of 4728 kg, mounted on the "Vostok" rocket.

The payload consisted of the "Vostok-4" spaceship-sputnik with the pilot-cosmonaut P. R. POPOVICH in his full space flight outfit to be put into orbit around the Earth.

The payload weight did not include the weight of the upper carrier-rocket stage.

Different elements of the "Vostok-4" spaceship-sputnik construction were weighed separately. They are: pilot seat, instruments compartment, spaceship-sputnik cabin and retrorocket system, spaceship-sputnik as a single unit and the pilot-cosmonaut P. R. POPOVICH in his full space flight outfit.

Weighing was made on the balance, type VH-10, No. 0741, with range of weighing from 500 kg to 10 tons.

Precision of weighing is illustrated by the following table.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

V. I. Bodrikov,
N. M. Tereshenkova,
calculating engineers

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T A B L E

Precision of weighing on balance, type AH-10, No. 0741

WEIGHT (kg)	PRECISION (kg)
500	± 2.5
1000	± 2.5
2000	2.5
3000	± 3.0
4000	± 4.0
5000	± 5.0

The balance were checked in accordance with the instruction 49-57 of the Committee of Standards, measures and measuring instruments at the Council of Ministers of the USSR, dated by the 26th of June, 1962.

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THE USSR FOBKAIOV CENTRAL AERO CLUB

STATEMENT

on the launching of the carrier-rocket with the "Vostok-4" spaceship

[redacted]

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COPY

THE COMMITTEE
OF STANDARDS, MEASURES AND MEASURING INSTRUMENTS
AT THE COUNCIL OF MINISTRY OF THE USSR
The state measuring instruments laboratory, AURDI

CERTIFICATE No. 848
on the state test of stop-watch No. 26

Range of measurements 60 sec. 30 min.

Type "Omega"

Manufacturer

Possession: the USSR Tekhnikov Central Aero Club.

On the basis of state tests the instrument was adopted for use in the second class.

Laboratory Chief sign. (Shagko)

S. P. *State representative who made verification sign.* (Menshova)

On 13th of March, 1962.

THE RESULTS OF STATE TESTS

Corrections for the stop-watch:

the dial upward, per 60 sec. 00
" " " , per 30 min. 00
the head upward, per 60 sec. 00
" " " , per 30 min. 1,2

The null position of the second needle 0,0 sec.

Temperature + 20° C

State representative who made verification sign. (Menshova)

The certificate is copied exactly. *The executive secretary of the sports commission of the USSR Tekhnikov Central Aero Club* (Gubaranov V. M.)

12 March 1962

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the landing of pilot-cosmonaut Pavel Romanovich POPOVICH and the "Vostok-4" spaceship-sputnik

On the 15th of August, 1962, I, the undersigned Nikolai Konstantinovich MIKHIN, sports commissar of the USSR Tchkalov Central Aero Club, bear witness to the fact, that on the 15th of August, 1962, at 6:16:21 a. m. GMT pilot-cosmonaut Pavel Romanovich POPOVICH was jettisoned from the "Vostok-4" spaceship-sputnik and at 6:59:00 a. m. GMT landed in the vicinity of the settlement Atasu, Karaganda region.

Spaceship-sputnik with the identifying marks "USSR Vostok-4" landed at 6:50:37 a. m. GMT in the above mentioned region.

Time measurement was carried out with the stop-watch, type "Omega", No. 26.

Geographical coordinates of the landing place of the pilot-cosmonaut P. R. POPOVICH.

48 40'00" N. Lat.
71 51'00" E. Lon.

Geographical coordinates of the "Vostok-4" spaceship-sputnik landing place:

48 09'00" N. Lat.
71 51'00" E. Lon

N. K. Nikitin.
sports commissar of the USSR Tchkalov Central Aero Club

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on the defining of flight range of the "Vostok-4" spaceship-sputnik, piloted by the pilot-cosmonaut Pavel Romanovich POPOVICH August 12-15, 1962

We, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club, and Alexandra Ivanovna SRAGOVICH, department chief of the Coordinating Computation Centre, have drawn up the following statement:

On the basis of studying the results of processing the data measured during the "Vostok-4" spaceship flight on August 12-15, 1962, by the Coordinating Computation Centre, we established the following.

The flight range of the "Vostok-4" spaceship-sputnik with the pilot-cosmonaut Pavel Romanovich POPOVICH on board amounts to 1081050 km.

I. G. Borisenko.
N. K. Nikitin.
sports commissars of the USSR Tchkalov Central Aero Club

A. I. Sragovich.
department chief of the Coordinating Computation Centre

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THE USSR TCHKALOV CENTRAL AERO CLUB

STATEMENT

on defining the flight duration of the "Vostok-4" spaceship, piloted by cosmonaut Pavel Romanovich POPOVICH August 12-15, 1962

We, the undersigned Ivan Grigoryevich BORISENKO and Nikolai Konstantinovich NIKITIN, sports commissars of the USSR Tchkalov Central Aero Club have drawn up the following statement:

On the basis of the statements of launching and landing the "Vostok-4" spaceship and on the basis of studying the results of data processing of the measurements taken during the "Vostok-4" spaceship flight with pilot-cosmonaut Pavel Romanovich POPOVICH on August 12-15, 1962, by the Coordinating Computation Centre, we have established the following:

The total flight duration of pilot-cosmonaut Pavel Romanovich POPOVICH from the moment of launching the rocket with the "Vostok-4" spaceship till the moment of jettisonning the pilot-cosmonaut from the "Vostok-4" spaceship is 70 hours, 43 minutes, 48 seconds.

I. G. Borisenko,
N. K. Nikitin,
sports commissars of the USSR Tchkalov Central Aero Club

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THE COORDINATING COMPUTATION CENTRE

"MOSCOW COSMOS"

The "Vostok-4" space flight on August 12-15, 1962: Orbital data processing results; spaceship's flight range

Orbital data processing for the "Vostok-4" space flight on August 12-15, 1962, was carried out with the help of the M-20 and "Strela" electronic computers in accordance with the technique given below. The processing made it possible to find out the following parameters:

1. The minimum flight altitude above the Earth's surface during the first orbit:

H_{min} 179.8 km

Geodetic coordinates of the minimum altitude point are:

φ 35°49'30" N. Lat.

λ 32°35'10" E. Lon.

2. The maximum flight altitude above the Earth's surface during the first orbit:

H_{max} 230.7 km

The geodetic coordinates of the maximum altitude point are:

φ 63°49'15" N. Lat.

λ 86°55'50" W. Lon.

3. Geodetic coordinates, time (GMT) and flight altitude above the Earth's surface for the two points of the first orbit are:

φ 47°.2 N. Lat.	φ 49°.2 N. Lat.
λ 42°.2 E. Lon.	λ 155°.2 E. Lon.
H 180.0 km	H 188.0 km
t 9 hr. 36 min. 00 sec.	t 9 hr. 53 min. 00 sec.

4. Orbital parameters of the first orbit:

major semiaxis

a 6578350 m

eccentricity

ϵ 0.004380

inclination

i 64°57'10"

perigee angular position

ω 84°09'23"

longitude of ascending node

Ω 116°42'45"

time of passing through perigee

τ 9 hr. 32 min. 40 sec.

time of passing through ascending node at the end of the turn

t 9 hr. 22 min. 52 sec.

period

T 88.390 min.

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5. "Vostok-4" velocity in the minimum and maximum altitude orbital points during the first orbit was 7.82 km sec. and 7.72 km sec. respectively.

"Vostok-4" velocity just before the retrofiring was 7.85 km sec.

6. "Vostok-4" orbital parameters evolution.

Parameters	12.VIII 1st orbit	13.VIII 17th orbit	14.VIII 33rd orbit	15.VIII 48th orbit
Period (min.)	88.390	88.310	88.224	88.133
Maximum altitude (km)	230.7	231.7	226.4	220.4
Minimum altitude (km)	178.8	177.4	174.7	171.4

The maximum flight range calculated on the basis of orbital data and with the use of the technique described below was found to be 1981050 km. This range was measured from the point of the spaceship lift-off to the point of the cosmonaut's separation from "Vostok-4".

APPENDICES: 1. The technique of "Vostok-4" flight range calculation.
2. The technique of data processing of orbital measurements obtained during the "Vostok-4" spaceship flight.

Gparohir - *A. I. Sragovich,*
department chief, the
Coordinating Computation Center

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Technique of flight distance determination of the "Vostok-4" spaceship

The flight distance of the spaceship was calculated on M-20 and "Strela" electronic computers.

The flight distance was defined as the sum of distances of three flight phases:

$$L = L_p + L_{cm} + L_d,$$

where L — total flight distance;

L_p — flight distance from the launching point to the point of cutting off the upper stage of the carrier-rocket;

L_{cm} — flight distance from the point of cutting off the upper stage of the carrier-rocket to the point of firing the retrorocket.

L_d — flight distance from the point of firing the retrorocket to the point of jettisoning the pilot-cosmonaut from the spaceship-sputnik.

Distance from each phase was estimated according to the following:

$$L = \int_{t_a}^{t_b} \sqrt{V_x^2 + V_y^2 + V_z^2}\, dt,$$

where t_a, t_b — time of beginning and finishing the movement on a given phase;

V_x, V_y, V_z — spaceship velocity vectors components in the Cartesian coordinates;

V_x, V_y, V_z — of the powered flight phase were estimated from the movement equations of the carrier-rocket of the "Vostok-4" spaceship. The time of finishing the powered flight was defined from the telemetering data received from the airborne instruments during this phase.

Besides, a correction was introduced into the actual coordinates at the end of powered flight phase in accordance with measurement data of spaceship movement parameters made by ground metering stations.

In the Earth-satellite orbital flight phase V_x, V_y, V_z were defined by solution of the boundary problem of the point movement in the gravitation field of the rotating Earth.

The initial data for the boundary problem solution were the results of measurements of the spaceship movement parameters. This solution was carried out in accordance with the technique described below.

V_x, V_y, V_z for the phase from the moment of firing the retrorocket till jettisoning the pilot-cosmonaut from the spaceship-sputnik were estimated by solving the equations of motion according to the initial phase and introducing corrections with respect to the actual coordinates of the jettisoning point. The flight distance was defined in the coordinate system which moves in space together with the centre of the Earth.

V. I. Semyonov,
department chief of the
Coordinating Computation Centre

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The technique of "Vostok-4" orbital parameters calculation

The following basic assumption on the spacecraft's motion were made to determine its orbital parameters. The satellite is treated as a mass point moving under the action of the Earth's gravitational force and the air drag one.

Expanding the g potential into spherical functions two components were taken into account, viz.: the uniform sphere potential and the term incorporating the Earth's flatness. Anomalies of the gravitational field were ignored.

The air drag deceleration was found by the formula:

$$a = \kappa_1 \varepsilon V^2, \qquad (1)$$

where V — a module of the vector of the satellite relative velocity,

ε — the air density at a given altitude,

κ — ballistic coefficient which value is determined by satellite weight and aerodynamic parameters.

The satellite is considered to move in $OXYZ$ Cartesian coordinates which are bounded rigidly to the rotating Earth. The origin of the coordinates is placed into the Earth's center, the OZ axis passes through the North Pole, the OX axis coincides with the Greenwich meridian and the OY axis is due East.

The satellite's orbital parameters were found on the basis of the processed tracking data by means of solving a boundary problem for the following system of the differential equations of motion:

$$\begin{aligned}
\dot{V}_x &= -\kappa_1 \varepsilon V V_x - g_r \frac{x}{r} + g_m \frac{z}{r} \frac{x}{r} + 2\Omega V_y \\
\dot{V}_y &= -\kappa_1 \varepsilon V V_y - g_r \frac{y}{r} + g_m \frac{z}{r} \frac{y}{r} - 2\Omega V_x \\
\dot{V}_z &= -\kappa_1 \varepsilon V V_z - g_r \frac{z}{r} - g_m \frac{z}{r} \frac{z}{r} \\
\dot{x} &= V_x, \quad \dot{y} = V_y, \quad \dot{z} = V_z, \qquad (2)
\end{aligned}$$

where $r = \sqrt{x^2 + y^2 + z^2}$, $r = \sqrt{x^2 + y^2}$, $V = \sqrt{V_x^2 + V_y^2 + V_z^2}$.

g_r and g_m are radial and meridional components of the Earth's gravity respectively (their positive values are to the center of the Earth for g_r and due south for g_m);

Ω — the Earth's angular velocity.

The initial data necessary to solve the boundary problem were the measured t_i, x_i ($i = 1, 2, \ldots, N$, where N is the total number of the measurements) and the calculated values of the initial motion parameters $\bar{y}_i^0$ ($i = 1, 2, \ldots, 6$) related to the moment $t = t_0$ of the spacecraft insertion into the orbit.

To determine t_i, x_i it was necessary to measure the range D, from the tracking station (TS) to the satellite, the azimuth A, of the "TS — satellite" line of sight and the tilt angle γ of this line. Measurements were carried out by the tracking stations situated on the territory of the USSR along the satellite track. The tracking stations were equipped with the radiotechnical systems, using the principle of active response from the satellite, and provided the necessary measuring precision

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The measured data of the tracking stations were at the same time [illegible] accurately correlated with the standard time. To find the corrections Δy_j ($j = 1, 2, \ldots, 6$) to the initial conditions of motion the least squares method was used which allowed to calculate the orbital parameters to the highest precision possible.

In case when the parameters D_i, λ_i and φ_i were measured for the coinciding points the following relations were accepted as temporary equations

$$\sum_{j=1}^{6} \frac{\partial r_i}{\partial y_j^{(m)}} p_i \Delta y_j^{(m)} = \Delta r_i p_i \qquad (i = 1, 2, \ldots, N_1). \tag{3}$$

where $\frac{\partial r_i}{\partial y_j^{(m)}}$ is a partial derivative of the measured parameters with respect to initial motion conditions, $p_i = \frac{1}{\sigma^2(r_i)}$ is the "weight" of the i-th measurement, N_1 is the number of measurements (out of their total number N) used in a given calculation

$$\Delta r_i = r_{i\,\text{measured}} - r_{i\,\text{calc}}.$$

Following some well known rules this system (3) of the temporary equations leads to the normal equations:

$$\sum_{n=1}^{6} Q_{mn} \Delta y_n^{(m)} = b_m. \qquad (m = 1, 2, \ldots, 6) \tag{4}$$

Resolving these last equations one can find the corrections $\Delta y_j^{(m)}$ ($j = 1, 2, \ldots, 6$) for the initial motion conditions.

The boundary problem is solved by iteration process. As a result refined initial motion conditions may be found by the formula:

$$y_n^{(m)} = \bar{y}_n^{(m)} + \sum_{l=1}^{l} \Delta y_n^{(m)}. \qquad (j = 1, 2, \ldots, 6). \tag{5}$$

where l is the number of iterations carried out until the complete convergence of the calculating process.

The refined initial motion conditions t_0, X_0, Y_0, Z_0 served as the basis for forecasting "Vostok-4" flight parameters. The latter is done by numerical integrating the motion equations (2) up to the time of retrofiring signal initiation, and after that moment by numerical integration of the motion equations taking into consideration the retrofiring.

The boundary problem was solved and the forecasting of the "Vostok-4" spaceship's motion was made with the help of the M-20 and "Strela" computers in the course of the spaceship's flight.

Later on to refine the orbital parameters tracking data of all the ground stations were treated completely and the precision of the basic orbital parameters was estimated.

Department chief,
Coordinating and Computing Center (A. I. Sraposch)

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THE USSR TCHKALOV CENTRAL AERO CLUB

REPORT

on the "Vostok-4" spaceship construction and its special equipment

The "Vostok-4" spaceship is a guided rocket vehicle which may be controlled both automatically and manually by the cosmonaut.

The spaceship consists of a pressurized cabin which houses the cosmonaut, of an instrument compartment and a retrorocket compartment.

There is a special heat shield on the outside of the pilot's cabin that protects the cabin against the high temperature on reentry.

The cabin is equipped with two quickly opened hatches.

The cabin's shell has three windows for the cosmonaut to use for observations. The windows are provided with refractory glass designed to withstand the high temperatures on the surface of the vehicle during reentry.

All the windows carry shutters which may be opened or closed either by an electrical drive or manually by the cosmonaut.

The spaceship's cabin houses a life-support system, a control system, food and water supplies, some of radio equipment, a binoculars for observations through the windows, TV cameras, a cinematographic camera for shooting a film through the windows and a cinematographic camera for shooting a film inside the spaceship.

The instrument compartment contains some radio equipment, control equipment, [illegible] temperature control system and an electrical power system.

In flight the cosmonaut is supported by a catapulted molded couch which is [illegible] taking place and may serve as a means for leaving the cabin before landing. Supporting surfaces of the couch are fitted with soft plastic cushions.

The couch contains parachute systems providing the landing of the cosmonaut.

[illegible] of water landing the cosmonaut may use a pneumatic liferaft inflated [illegible] gas.

[illegible] for some reasons the cosmonaut cannot make use of the raft after water [illegible], a special device in the pressure suit keeps the cosmonaut lying on his [illegible] the surface.

[illegible] the orbital flight ventilation of the cosmonaut's pressure suit is performed [illegible] air taken out of the cabin. In case of the cabin's decompression [illegible] automatically pressurized. In this case the reserves of the onboard compressed air provide the oxygen supply to the cosmonaut for breathing [illegible] the space suit. In case of decompression of the cabin [illegible] allow the cosmonaut enough time to establish radio [illegible] ground, to choose a place for landing and to descend.

[illegible] the temperature, humidity and atmosphere composition [illegible] controllers on the panel.

[illegible] and manual control systems allow the cosmonaut manually [illegible] to land the ship in the desired area.

[illegible] provides a proper attitude of the vehicle before [illegible] the system is divided operationally into an automatic one [illegible]

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An optical orienting unit used by the cosmonaut to find out the flight direction and the local vertical is mounted on one of the cabin's window.

The retrorocket with the control system is designed to [illegible] the magnitude and direction of the spaceship's velocity vector to transfer it from the circular satellite orbit to a descending trajectory.

The retrorocket may be activated both automatically and at pilot's choice by means of a switch on the instrument panel.

The flight control system provides automatic control of onboard instruments according to a prescribed programme.

The spaceship is equipped with radio equipment for two-way communication of the cosmonaut and ground stations during prelaunch operations, powered flight and orbital flight.

The radio equipment includes two short-wave receivers and two short-wave transmitters, a tape recorder, a broadcast receiver and electroacoustic equipment.

The frequencies of the onboard transmitters are 18.035, 20.006 and 143.625 megacycles per second.

The type of communication is chosen by the pilot switching on the proper radio system.

The tape recorder is switched on either automatically by the cosmonaut's voice sound or manually.

Tape recorded data are radioed to the ground at an increased speed by the command from a receiving station when the spaceship is over it.

Orbit radio control equipment for the powered and orbital phases consists of receiving and transmitting signal forming instruments and an antenna system.

The TV-system is designed for watching the cosmonaut and receiving objective data on his state, behaviour, movement coordination while performing various operations.

Instruments for monitoring and recording physiological functions of the cosmonaut in flight, viz.: pulse rate, respiration, etc., allow to conduct continuous observations of the cosmonaut's state.

Radio and telemetering equipment, self-contained registration system and sensors provide monitoring and recording of the onboard instruments performance in flight. In addition the spaceship carries the "Signal" radio system operating on the frequencies of 19.995 and 19.990 megacycles per second.

To maintain the basic microclimate parameters in the cabin within the limits close to normal a conditioning system is used, which absorbs carbon dioxide and moisture, and supplies the necessary amount of oxygen for pilot's respiration. The oxygen flow rate in the system is controlled automatically.

The conditioning system also absorbs the harmful contaminations which result from human life activity and instrument operation.

Normal cabin pressure is maintained with the help of a pressure control system.

The food and water supply systems provide the pilot with food and water throughout flight.

The pilot has a four-meal diet.

A special sanitary unit is designed for collection of liquid and solid excretion products.

The automatic temperature control system is installed aboard the spaceship to maintain the temperature regime within given limits.

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The system consists of two loops: an air-loop opened into the cabin and a liquid one connected with a radiating heat source mounted on the instrument compartment. Both loops are connected to an air-liquid heat exchanger located in the cabin.

Such a system ensures the maintenance and control of the cabin temperature by the cosmonaut within the range of 12 to 27 C.

The cabin light system includes the "on-duty" illumination and the operational one. Illumination is controlled by switches on the instrument panel and may be turned on and off by the pilot.

The system provides illumination from 5 to 70 luxes.

The landing system ensures a safe landing of the spaceship and the pilot during the last phase of descent.

A device for determining by the pilot of the spaceship's position in orbit and geographic coordinates of the expected landing point is made in the form of a globe scaled down to 100,000,000 times.

The globe rotates simultaneously around two axes. Rotation around one axis corresponds to the Earth's rotation axis taking into account corrections for the precession of the spaceship's orbit. Rotation about the second axis corresponds to the orbital movement of the spaceship.

Thus every moment under the cross lines marked on the face glass of the instrument a place appears over which the spaceship is flying at this moment. Location of the expected landing point is carried out by turning the globe about its axis corresponding to the angle of descent from the point of firing the retro-rocket to the landing point.

The globe design permits to make necessary corrections to the instrument's readings in accordance with the real orbital parameters.

In contrast to the "Vostok" and "Vostok-2" spaceships the "Vostok-4" spaceship has the following modifications.

The spaceship carries an advanced TV-system to improve the quality of TV transmissions from the ship. The water supply system is modified.

In order the volume of information on the cosmonaut's state additional instruments measuring pilot's skin-galvanic reflexes, taking electroencephalogram and respiration diagram and transmitting them to the ground are set aboard the spaceship.

It is known that additional instruments for recording the ionizing radiation dose are set aboard.

The pilot's instrumentation panel is also improved and it allows the cosmonaut to control the work of the spaceship's systems.

The search, pressure suit and parachute system of the cosmonaut are modified to increase their reliability and accessibility.

Improved radios were introduced into onboard radio systems to provide communications between the "Vostok-3" and "Vostok-4" spaceships.

Besides the modifications mentioned above some improvements were made in the spaceship structure to increase the strength of some of its components and the structure as a whole.

Lieutenant Colonel V. I. Konstantinov
engineer

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THE USSR TCHKALOV CENTRAL AERO CLUB

Telemetry data from the "Vostok-4" spaceship

During the flight of the "Vostok-4" spaceship piloted by the Soviet cosmonaut Pavel Romanovich POPOVICH telemetery data were to be received pertaining to the following areas:

medical monitoring of the cosmonaut's state;
cabin environmental conditions monitoring;
cabin's radiation level;
monitoring of the manual-control system;
monitoring of the spaceship's attitude control system;
monitoring of the voice communication system;
monitoring of various instrumentation systems and the spaceship's structural components;

The recorded data from the corresponding sensors and instruments were transmitted by onboard transmitters during both powered and orbital flight phases and were received by ground tracking stations.

During the reentry and landing phases data were recorded by onboard selfcontained memory devices.

As a result of TM measurements and TM information processing the data were received on the above mentioned areas of investigation during every period of TM contact with the spaceship from the "Vostok-4" spaceship take-off and to the landing of pilot-cosmonaut P. R. POPOVICH.

Every period of radio contact lasted 5 to 20 min. and the total time of telemetering contact during the "Vostok-4" spaceship's three days flight ammounts to some 100 minutes.

Medical monitoring of the cosmonaut's physiological state was carried out with the help of the telemetering system on the basis of the following biological characteristics:

electrocardiogram;
pneumogram;
electroencephalogram;
electrooculograms;
skin galvanic reflex

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At the same time a special radiotransmitter continuously [illegible] cosmonaut's pulse rate.

Below is shown a portion of the cosmonaut's electrocardiogram, pneumogram, electroencephalogram and electrooculogram.

The mean values of the pilot's pulse and breathing rates on the various flight phases are listed in table 1.

The data given in table 1, on P. R. POPOVICH'S basic physiological responses are within the same limits as in normal ground conditions and during training.

Table 1.

Flight phases	Pulse rate beats/min.	Breaths per min
PRE-LAUNCH PHASE	117	16
POWERED FLIGHT PHASES		
at the beginning of the powered flight	124	17
at the end of the powered flight	118	20
ORBITAL FLIGHT		
2nd orbit	75	21
18 "	52	17
34 "	55	15
46 "	62	21
BRAKING	130	21
REENTRY	150	27

The state of respiratory system, of blood circulation, vestibular system and the central nervous system were normal.

Apart from the medical monitoring radio-telemetering systems recorded the readings of sensors controlling the climatic conditions of the flight, the spaceship components' functioning and orientation and control of the ship in flight.

The processed telemetery data in the areas mentioned above are given in table 2.

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Table 2.

No.	Characteristic	Units of measure	Phases: launch (up to 200 km)	orbital flight	descent	Precision
1	Air pressure in cabin	mm Hg	770	770 ÷ 760	760 ÷ 500	± 10 mm
2	Pressure in pressure suit	mm Hg	770	770		± 10 mm
3	The cabin air temperature	°C	28	28 ÷ 12		± 1°C
4	Cabin air composition oxygen carbon dioxide		22 0.30	22 ÷ 25 0.3 ÷ 0.6	25	± 2% 0.1%
5	Cabin humidity		60	60 ÷ 40		
6	Robot operator	mrad/day		12		± 1

Precision of TM system is ± 1% of measured range.

Telemetery information processing was performed with the use of calibration data which allow to make the results of measuring and processing more precise.

The sensors were calibrated during the plant and general tests of "Vostok-4" together with radio telemetery systems.

Some of the calibration plots are given below.

Engineer Ushanov *(S. M. Ivanov)*

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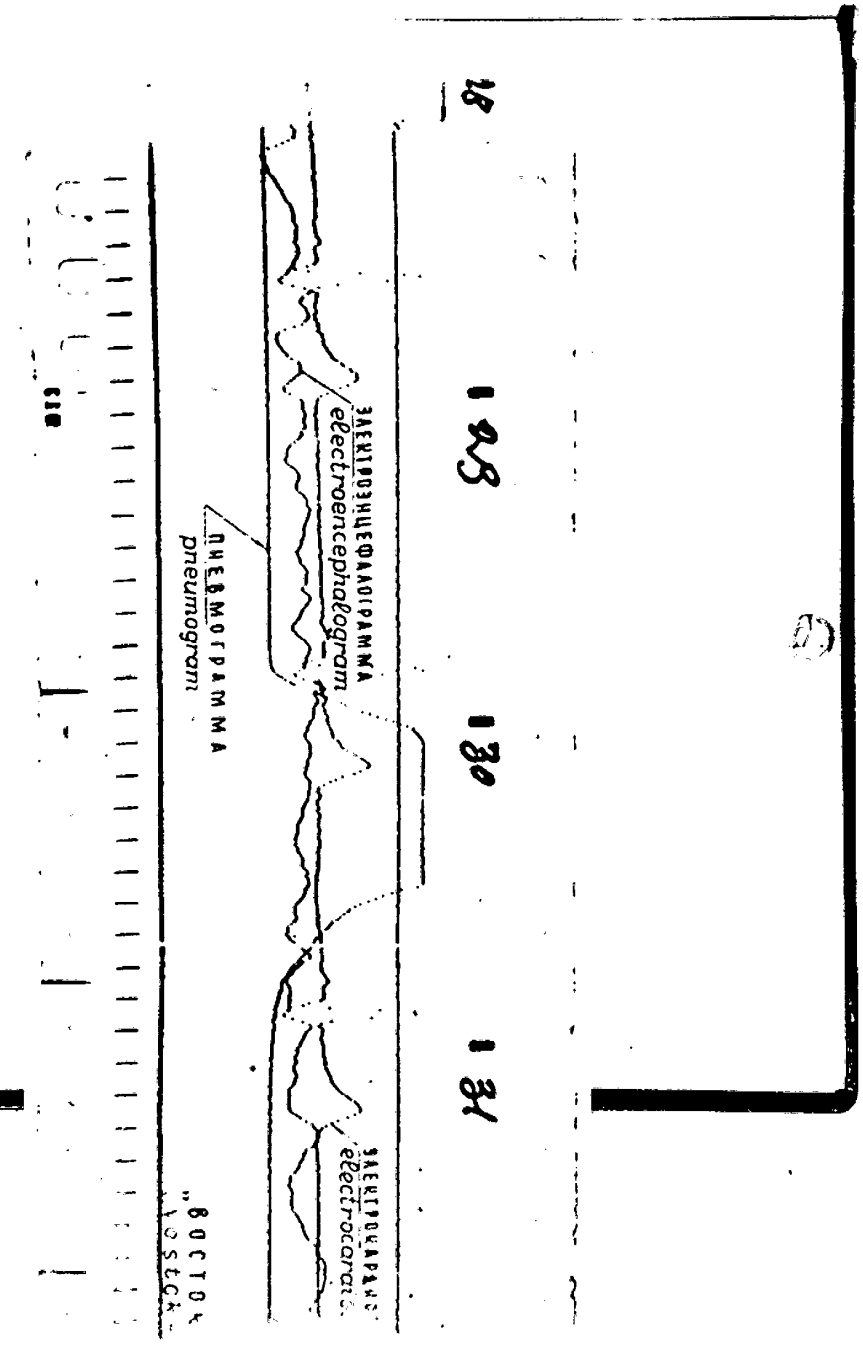

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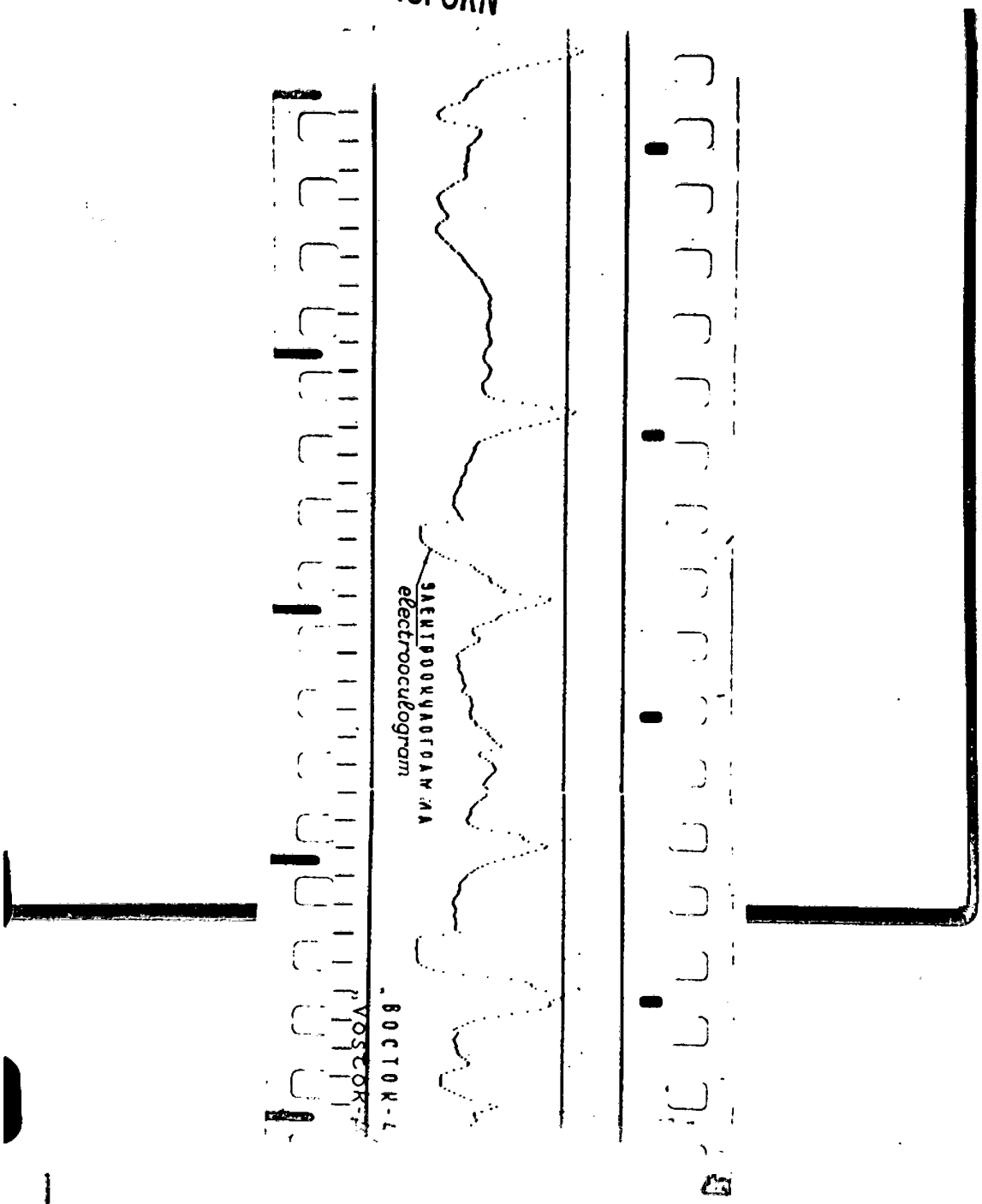

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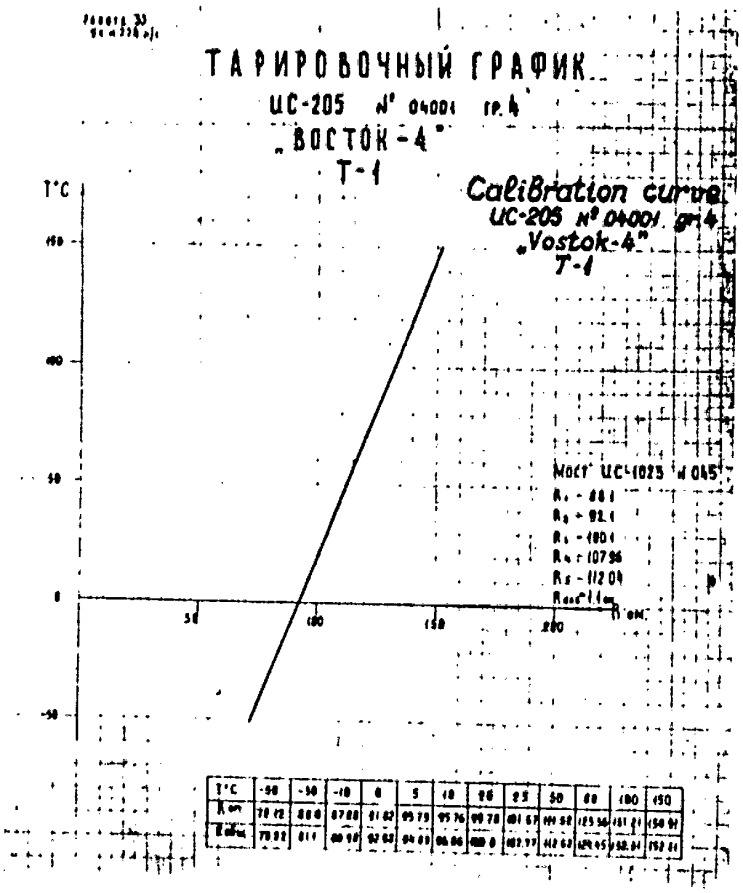

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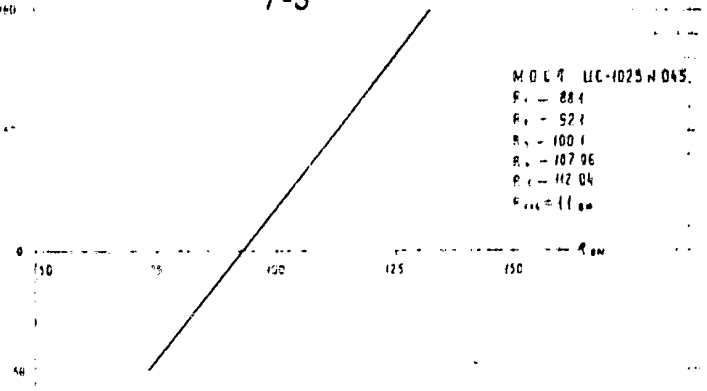
ТАРИРОВОЧНЫЙ ГРАФИК

УС-205 N 040191

ВОСТОК-4

Т-3

Calibration curve
УС-205 N 040191
„Vostok-4"
T-3



	0	5	10	20	35	50	80	100	120
	95 64	97 65	101 61	103 36	105 51	125 42	155 96	155 22	
	94 89	95 66	100 8	102 77	112 62	124 45	152 91	152 86	

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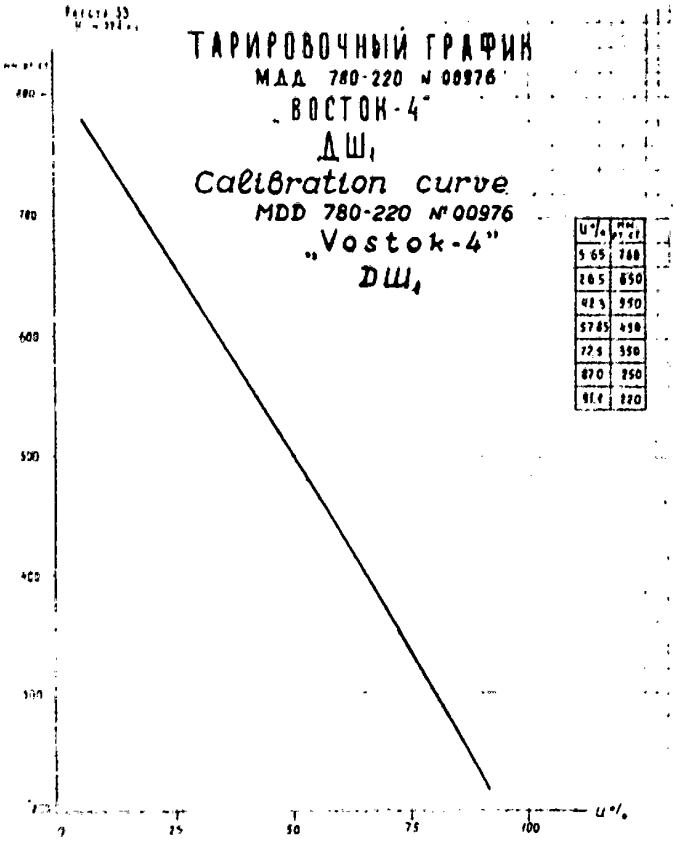

u %	мм рт. ст.
5.65	768
26.5	650
42.5	540
57.85	450
72.5	350
87.0	250
91.6	220

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CALIBRATION TECHNIQUE

a) Of ground stations.

Comparison of radar range with geodetic range measured with the precision of 0.2 meter.

b) Of airborne device.

Comparison between the radar range measured from the location of the radar station to the satellite antennas when the satellite is in the launching position and the geodetic range between these objects excluding instrument delays of radar stations measured according to the item "a".

c) Calibration of delay time in measuring signal level

The change of signal level causes variations in the delay time of a signal in measuring instruments, which leads to errors in range data.

Since these errors were neglected while measuring the "Vostok 4" coordinates the values of these errors must be provided to be small enough.

For this purpose appropriate calibrations were made confirming the small values of the errors mentioned.

Calibration was carried out by recording signal delay time while changing signal intensity. The recording of the variations in the delay time of a signal in the measuring systems versus signal intensity (in strength) within the range of 40 decibel are presented in the calibration diagram.

The delay-time variations from the mean value are plotted along the vertical axis, the signal intensity variations are plotted along the horizontal axis.

Calibration levels of delay time in microseconds (+ 0.01; 0.01; + 0.02; 0.02) are given at the beginning of the plot.

The calibration confirmed the possibility of neglecting errors caused by signal delay time instability in the range channel.

The maximum error was less than ±0.01 microsecond (± 1.5 meters).

B. A. Fedorov, engineer

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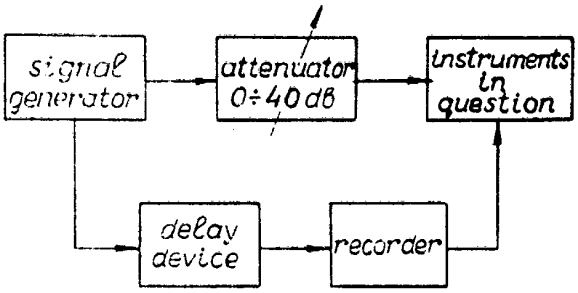
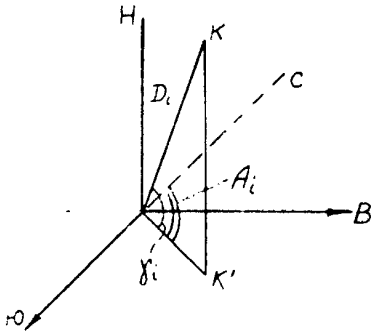
Delay time calibration





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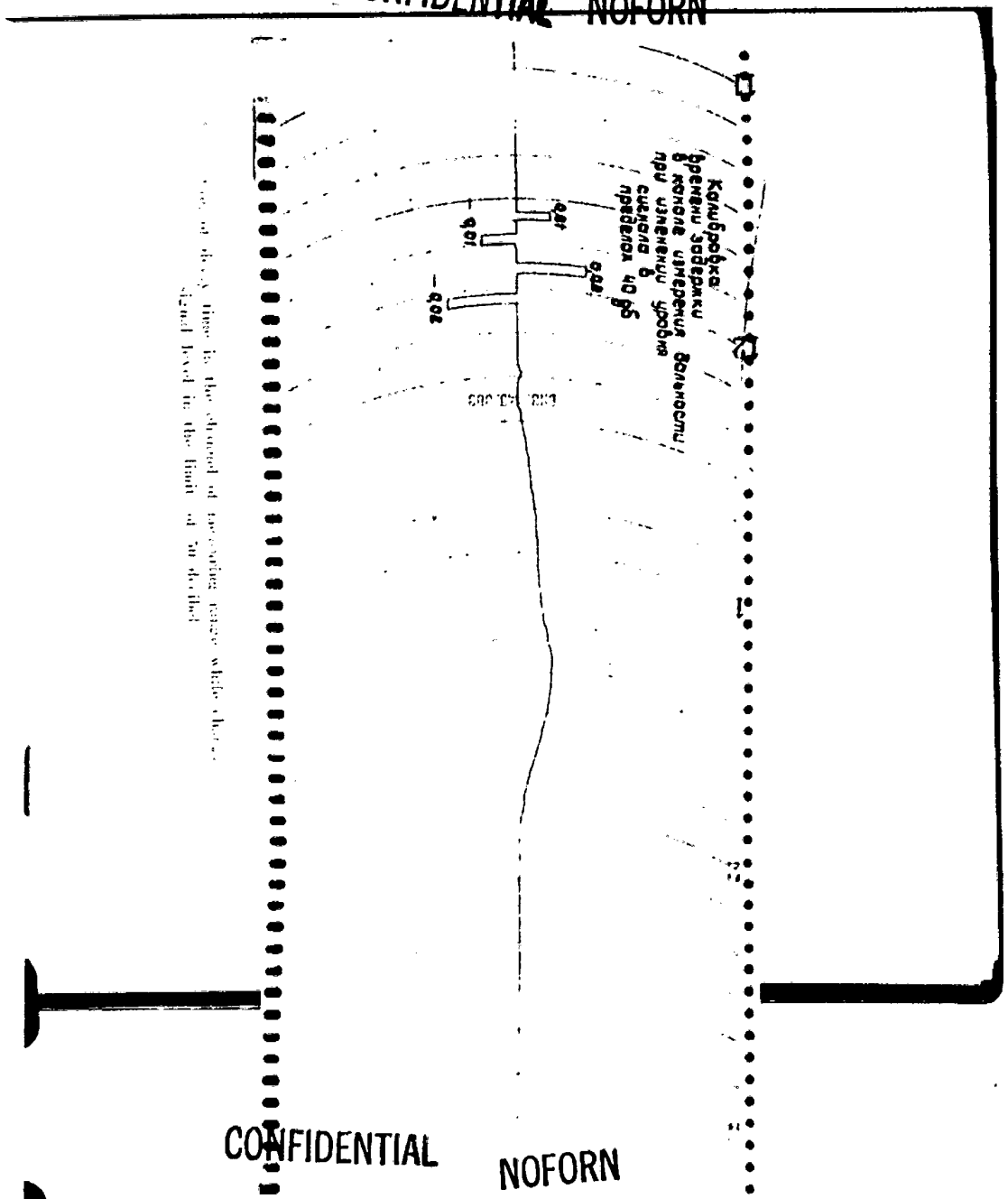

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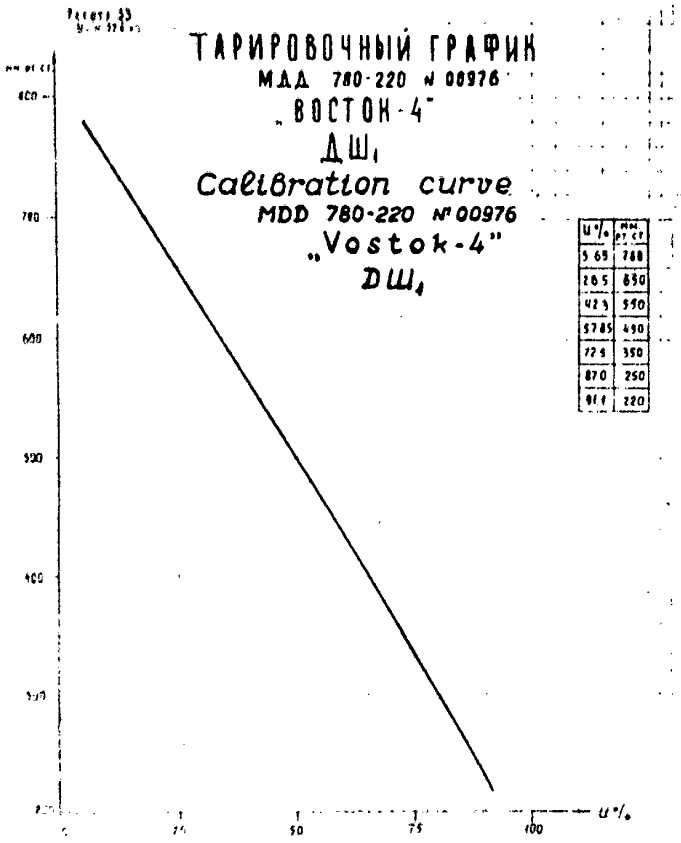

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B. A. Fedorov, engineer

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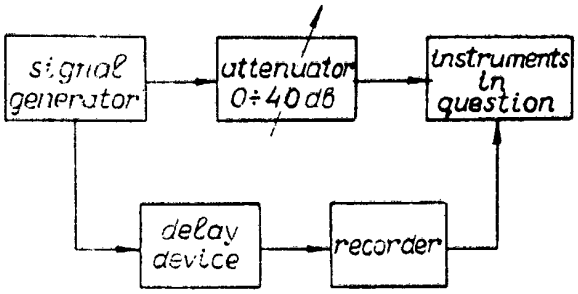

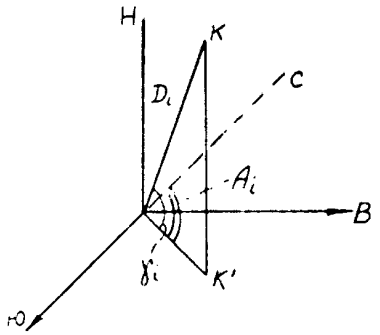

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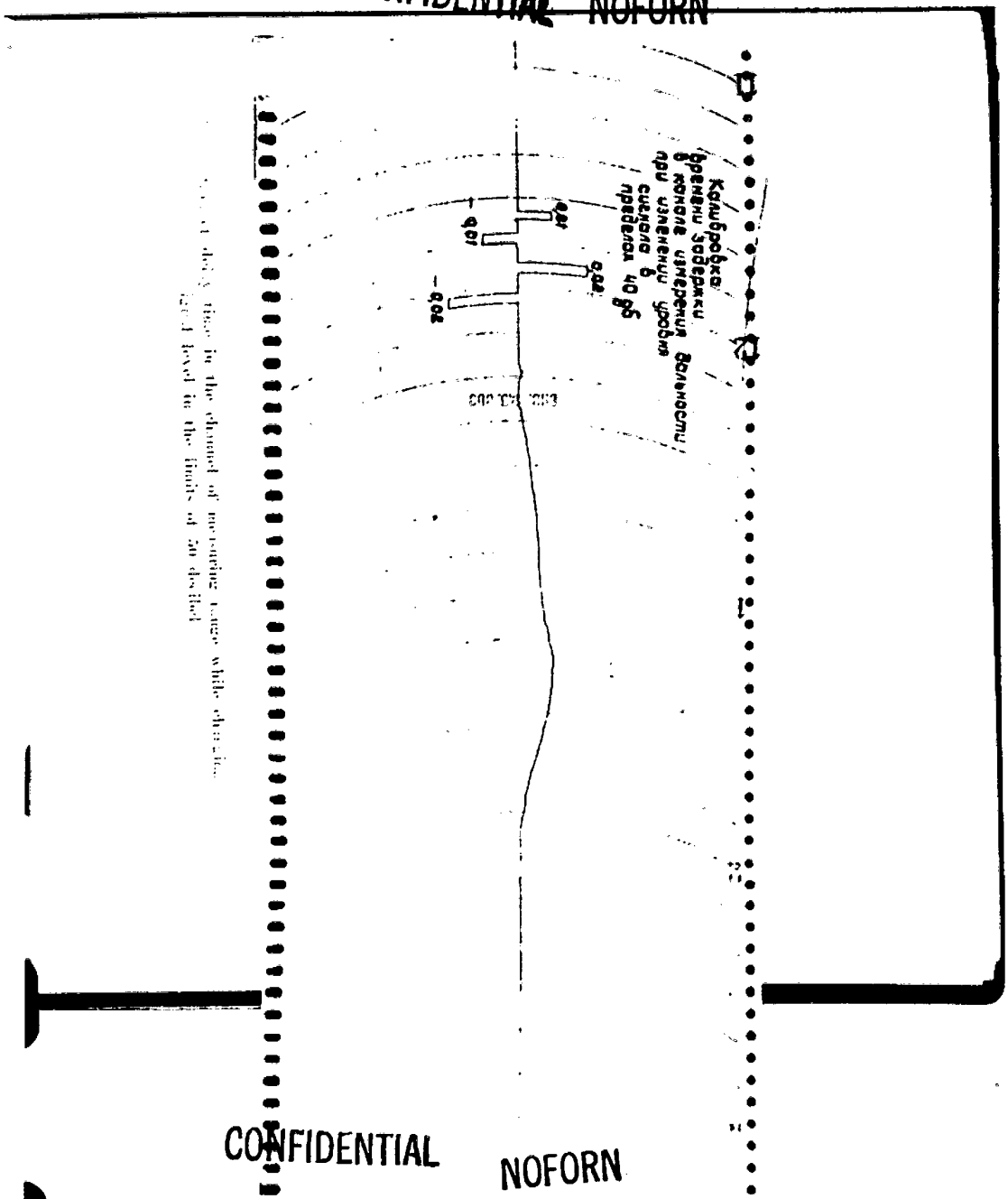

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THE USSR TCHKALOV CENTRAL AERO CLUB

DESCENT SCHEDULE

(Greenvich time)

1. At 5:53:00 a. m. the automatic descent system switched on the spaceship orientation system.
2. At 6:29:52 a. m. the automatic descent system fired the retrorocket.
3. At 6:46:49 a. m. the automatic descent system explored the catapult hatch lid and in 2 seconds the parachute system was automatically released. The catapult hatch lid was explored at the altitude of 7 km.
4. At 6:46:34 a. m. the automatic descent system switched on the spaceship landing system.
5. At 6:59:00 a. m. the landing of the pilot-cosmonaut took place.
6. At 6:50:37 a. m. the landing of the spaceship-sputnik took place.

Engineer B Tänning *(V. V. Galin)*

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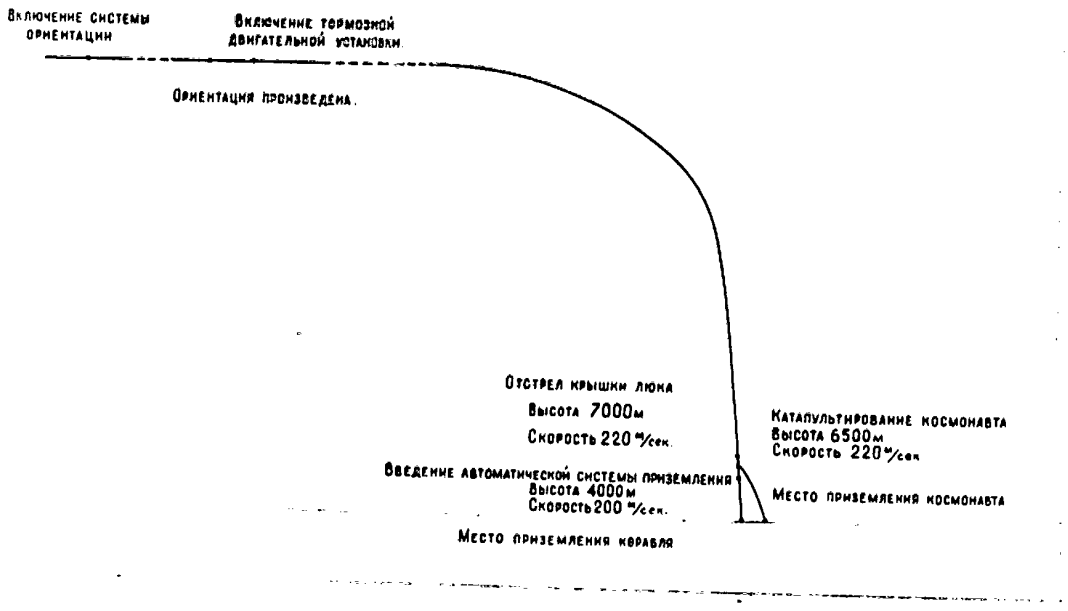
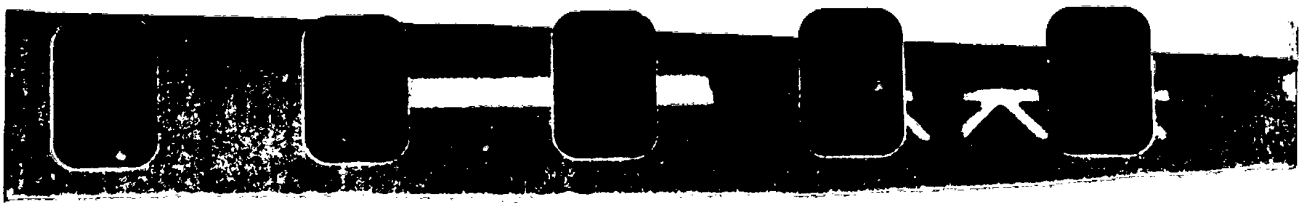
СХЕМА СПУСКА



Descent scheme



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THE USSR TCHKALOV CENTRAL AERO CLUB

FLIGHT PROGRAM

1. The spaceship take-off at 8:00:00 a. m. GMT, August 12, 1962.

The launching time is determined more accurately by means of the real orbital parameters of the "Vostok-3" spaceship.

2. Flight plan: 48 orbits around the Earth and landing on the territory of the USSR in the latitude of 48° N. Lat. The flight being normal, the landing is accomplished with the help of the automatic control system.

3. In case of bad feeling of the cosmonaut or failing some onboard apparatus the spaceship may be landed ahead of the prescheduled time by means of the manual controls or an automatic system.

The decision of landing before the appointed time using the manual controls is to be made after consulting to the ground stations. In case of communications failure the decision to land may be made by the cosmonaut independently.

4. In flight the cosmonaut maintains radio communications on HF and VHF.

The VHF communications are to be maintained within the operational range of the VHF stations.

The HF communications are to be maintained: during the first day every half an hour except for the period of sleeping; during the second and third days every hour at 00 min. Moscow time except for the period of sleeping.

The HF communications with the "Vostok-3" spaceship are to be carried out every half an hour at 00 min. Moscow time during the first, second and third days of flight (before the communications with the ground stations) and at 30 min. Moscow time (on the cosmonaut's call) except for the period of sleeping.

The cosmonaut may use the broadcast radio set.

5. During the orbital flight the cosmonaut is to perform the following operations:

to make checks and monitor the indicators, to carry out vestibular and psychological tests, to make physical exercises and medical self-observations;

to control the spaceship's attitude by means of the manual control system, to estimate orientation time, fuel flow rate, the spaceship's quiescing, comfort of working conditions and the easiness to maintain the spaceship in the proper attitude;

to conduct film shooting and scientific observations. Subjects of the film and observations are selected at the discretion;

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feeling fit once a day the cosmonaut is to [illegible] and to "float" during 50 to 60 min. to derive the greatest [illegible] king with the instruments in zero-g conditions; [illegible] position for making observations through the windows;

to make entries in his logbook and to record [illegible]

to monitor the functioning of the spaceship's [illegible]

according to the instructions from the Earth ti[illegible] the onboard clock and to check the cabin-globe;

to eat food and drink water four times a day, to [illegible] to estimate the unusual manner of taking food;

to inform the ground stations of the functioning of onboard [illegible] firing the retrorocket;

-- to catapult out of the cabin at the altitude of 6.5 km after [illegible] decelerating in the lower atmosphere (during reentry) and to land by [illegible]

The spaceship is to land without the pilot. On landing the [illegible] examine the ship and to radio of his landing.

In case the catapult fails the cosmonaut is to land in the cabin of the spaceship.

This flight plan was examined and adopted by the Presidium of the USSR Aero Sports Federation and the Sports Commission of the USSR [illegible] Central Aero Club.

Executive secretary of the Presidium of the USSR Aero Sports Federation [signature] *(V. P. Nanokin)*

Lieutenant-colonel pilot-cosmonaut [signature] *(P. R. Popovich)*

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REPORT

by Lieutenant-colonel Pavel Romanovich Popovich, USSR pilot-cosmonaut, on the "Vostok-4" space flight August 12 to 15, 1962

The launching vehicle carrying the "Vostok-4" spaceship with me aboard lifted off at 8:02:33 a. m. GMT on August 12, 1962.

I have normally withstood the g-loads, vibrations and noise effects of the powered phase of flight.

The spaceship was successfully placed into an orbit which was very close to the precalculated one. I knew the "Vostok-3" position with respect to my ship and could see it through the window.

Performing my flight program I established two-way radio contact with the ground and the "Vostok-3" spaceship. We exchanged the information of our conditions, of our observations and NIKOLAEV shared with me the experience gained for the first day of his flight.

The onboard broadcast receiver allowed me to listen to broadcasts of the Radio Moscow and other stations.

At 12:30 p. m. Moscow time A. G. NIKOLAEV and I reported to the Soviet people, the Central Committee of the CPSU, the Soviet Government and N. S. KHRUSHCHEV that the flight program was carried out successfully.

At 15:45 p. m. Moscow time I had a conversation by radio-telephone with N. S. KHRUSHCHEV. In flight I radioed greetings to my comrades, to the peoples of the Soviet Union, of Europe, Asia, Africa, Northern and Southern Americas and Australia.

In accordance with the flight program I released the restraining system of my couch, "floated" freely in the cabin and turned around myself. During the telecasts I showed the TV-viewers the weightlessness of the objects floating in front of the television cameras.

In the course of flight I made a lot of experiments in particular I watched the behaviour of water in space. I performed various self-observations following the program prepared for me by physicians; I made also physical exercises and kept strictly to the dayly routine of the flight program.

Throughout the flight I made observations, took pictures of the Moon and the Earth, made entries into my logbook. Watching the Earth from the orbital altitude I could clearly see cities, rivers, mountains, ships. Various shades and

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outlines on the Earth's surface allowed me to know what continents I flew over, where coast line was. Islands were bordered with a halo of bright green colour. I was especially impressed with the Moon which was full during my flight.

The spaceship's cabin provided me with exellent environmental conditions. The conditioning system ensured the purity of the cabin air, normal atmospheric pressure and humidity. The cabin temperature could be controlled at my will.

During the flight I had a good appetite. My food supply consisted of natural products, stored in tubes and small plastic bags and tasted exellently.

The flight program has been carried out completely.

At the end of 48th orbit the spaceship was properly oriented, the retrorocket fired and the spaceship went along the descent trajectory. While descending I activated landing system which jettisoned my couch off the spaceship and I landed by parachute. This phase of descent I withstood without any difficulties and landed quite safely.

At the landing place I was met by the representatives of technical support and rescue services, physicians, correspondents and a sports commissar.

At present I feel well and notice no ill effects or changes in my organism.

Lieutenant-colonel, pilot-cosmonaut (Popovich P. R.)

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[illegible] of the USSR
hero [illegible] Pavel Romanovich POPOVICH

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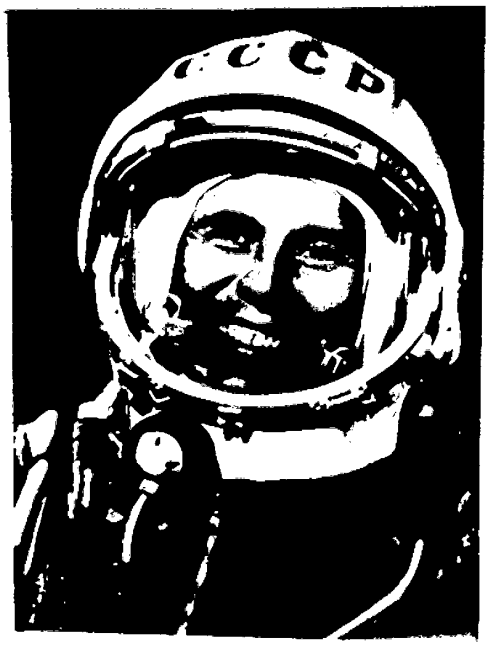

Pilot-cosmonaut P. R. POPOVICH
in pressure suit

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Pilot-cosmonaut P. R. POPOVICH
on the way to the cosmodrome

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Pilot-cosmonaut P. R. POPOVICH
during the flight

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Pilot-cosmonaut P. R. POPOVICH directly after the landing is reporting by telephone to the Head of the USSR Government N. S. KHRUSHCHOV about the successful complement of the space flight

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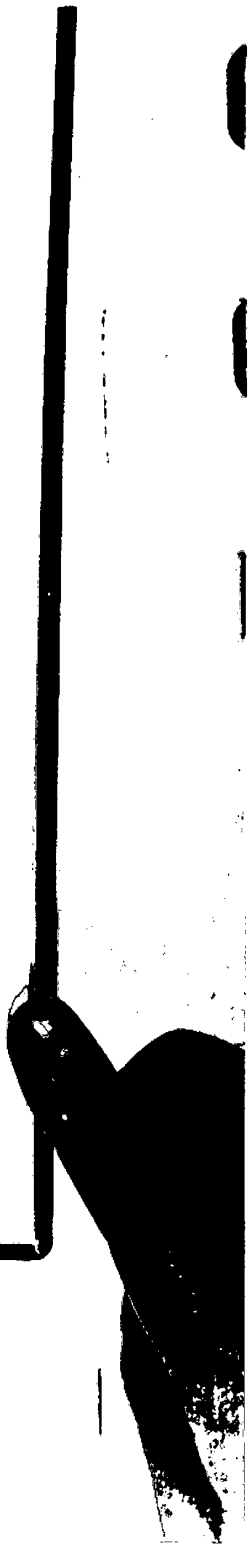
PICTURES

taken with the movie camera
from the spaceship-sputnik "Vostok-4"
by pilot-cosmonaut P. R. POPOVICH
12-15 August, 1962



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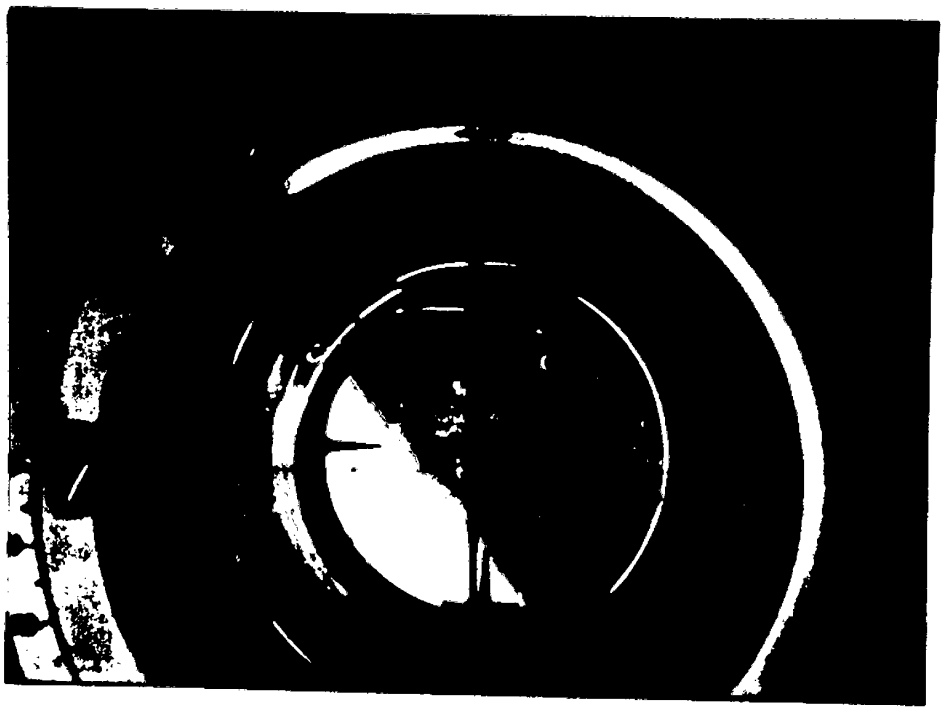

Horizon taken through the optical orienting unit

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Mountain ridge

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Horizon. The spaceship's antenna is seen in the lower part of the picture

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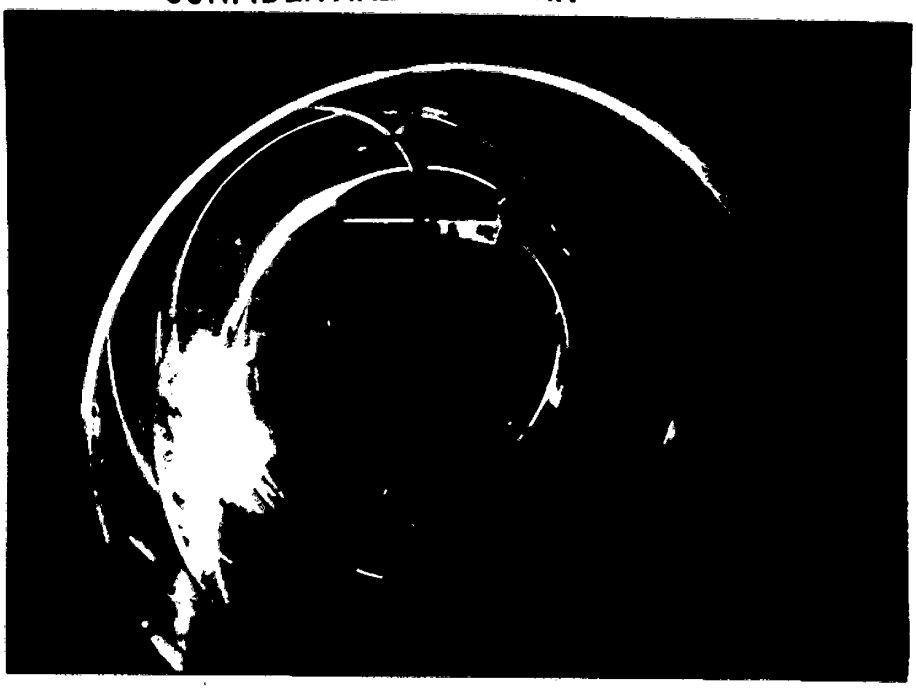

Sun taken throught the optical orienting unit

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Sea coast

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Mountain chain

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